TABLE OF CONTENTS

PAGE

LIST OF TABLES

PAGE

SECTION 4
ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

This section provides an analysis of potential impacts to the natural and human environment that could result from implementation of the proposed action and alternatives and FFD alternatives. The analysis is based upon consideration of existing conditions in the affected environment and potential effects of construction, operation, and abandonment of project components such as roads, bridges, production pads, processing facilities, airstrips, pipelines, and power lines. The comparison of the impacts by alternative is located in Table 2.7-1. Included in the table is a comparison of impacts from spills for each resource, by alternative. Potential mitigation measures that could be used to avoid or reduce impacts are also introduced and described.

Portions of the analysis have required development of predictive models to simulate potential impacts. The assumptions, guidelines, and methods used to conduct such analysis are stated to provide the reader with a basis for understanding and judging the reliability of the analysis. Other parts of the analysis have been conducted through consideration of government regulatory standards, available scientific documentation, and the professional judgment of resource specialists.

4.1.1 ORGANIZATION OF IMPACT ANALYSIS

SECTION 4.2

Section 4.2 introduces existing and potential additional mitigation measures that may be applicable to portions of the proposed action and alternatives and FFD alternatives through lease stipulations or applicability of the ROD for the Northeast National Petroleum Reserve-Alaska IAP/EIS.

SECTION 4.3

Section 4.3 presents an analysis of the probability and potential impacts of oil and salt water spills. Although spills are not a part of the proposed action or alternatives and FFD alternatives for the Plan Area, they could occur as a result of the proposed action and alternatives and result in impacts to the environment.

SECTIONS 4A, 4B, 4C, AND 4D

Sections 4A, 4B, 4C, and 4D present the impact analysis for Alternative A, Alternative B, Alternative C, and Alternative D, respectively. Each of these sections first presents an analysis of the CPAI Development Plan alternative, followed by analysis of the FFD alternative that is based upon the same theme. For the purpose of analysis, production pads and processing facilities associated with FFD alternatives have been organized into three facility groups:

Colville River Delta Facility Group

HP-4, HP-5, HP-7, HP-8, HP-12, HP-13, HP-14

Fish-Judy Creeks Facility Group

HP-1, HP-2, HP-3, HP-6, HP-9, HP-10, HP-11, HP-15, HP-16, HP-17, HP-19, HPF-1

Kalikpik-Kogru Rivers Facility Group

HP-18, HP-20, HP-21, HP-22, HPF-2

SECTION 4E

Section 4E presents an analysis of the No-Action Alternative. Under this alternative, the proposed action (Alternative A) or Alternatives B, C, or D would not be authorized and would therefore not be constructed or operated.

SECTION 4F

Section 4F presents an analysis of the agency preferred alternative. This alternative includes components common to other alternatives and new components designed to further mitigate impacts.

SECTION 4G

Section 4G presents an analysis of cumulative impacts. By definition, cumulative impacts are impacts that would result from the proposed action or alternatives in combination with other past, present, and reasonably foreseeable actions in the affected environment.

SECTION 4H

Section 4H presents a disclosure of other impact considerations, including unavoidable adverse impacts; relationship between local short-term uses and maintenance and enhancement of long-term productivity; and irreversible and irretrievable commitment of resources.

4.2 EXISTING AND POTENTIAL ADDITIONAL MITIGATION MEASURES

Any oil development in the ASDP Area would incorporate design and operation measures that would protect the environment. These measures would reflect the applicant's proposal, applicable federal, state, and NSB laws and regulations, and requirements of the leases that the applicant plans to develop. In addition, the federal RODs issued following completion of this EIS, the State of Alaska Coastal Consistency Review, and any federal, state, and borough permits necessary to authorize development could impose additional mitigation measures.

In its proposal, CPAI includes several measures to protect the environment. The most significant are provisions for pipeline valves on either side of larger river channels to minimize spill size in the event of a leak or break, placement of gravel roads downhill from the pipeline to aid in control of potential pipeline leaks, and installation of bridges rather than culverts across major waterways to ensure fish passage and minimize changes to riparian habitat. Additionally, CPAI proposes to minimize the size of gravel pads at production sites to reduce the project footprint, places a heavy reliance on winter construction and ice road use to minimize tundra damage, proposes a winter-only drilling plan for the lower Colville River Delta production pad to minimize impacts to nesting or molting bird populations, and maintains and enforces company rules against employees hunting, fishing, or disturbing wildlife.

Federal, state, and NSB laws and regulations also mitigate impacts. Many laws and regulations mandate certain protections for the environment. For example, regulations pursuant to the federal Clean Water Act establish limits for the discharge of pollutants. Regulations promulgated to enforce the National Historic Preservation Act and its Alaska counterpart mandate cultural resource surveys and avoidance measures to protect important archaeological and historic resources. State law and regulations prohibit habitat degradation in anadromous waters. The NSB requires that pipelines be no less than 5 feet above the tundra. (See Table 1.1.4-1 and Appendix C for a more complete list of authorities that provide environmental protection.)

In addition, the applicant is bound by the conditions of the leases purchased. Federal lease stipulations are listed in Appendix D. These include a wide variety of provisions, such as restrictions on oil development activities in certain areas and at certain times. Stipulated state mitigation measures vary by lease, but generally include restrictions on development during snow-free seasons, restrictions on development near or in critical habitat or use areas, and requirements for agency review and approval of development and operation plans.

The following analysis of impacts assumes the protections provided by the applicant's design; by federal, state, and NSB law and regulation; and by lease stipulations. Impacts identified under each alternative could occur despite these protections. In order to further mitigate impacts, this section also identifies potential additional mitigation measures. These mitigation measures are identified under each alternative following the discussion of potential impacts for each resource or use. The BLM ROD will identify which mitigation measures the BLM will adopt. Cooperating agencies could adopt mitigation measures as part of their RODs.

Unless granted an exception or a modification of the Northeast National Petroleum Reserve-Alaska IAP/EIS as part of this EIS, activities on BLM-managed lands must be conducted and facilities sited in accordance with the ROD for the Northeast National Petroleum Reserve-Alaska IAP/EIS development stipulations (Appendix D). These stipulations were developed to minimize environmental impacts that could result from oil and gas development activities on federal lands within the Northeast National Petroleum Reserve-Alaska. Measures presented in the Northeast National Petroleum Reserve-Alaska stipulations are actions that could also minimize impacts to the environment on state and private lands included in the ASDP Area and could be applied by the cooperating agencies to the proposed action and alternatives and FFD alternatives as mitigation measures. The Northeast National Petroleum Reserve-Alaska stipulations that would also mitigate impacts on state and private lands are hereby incorporated by reference into the mitigation sections of the EIS.

4.3 IMPACTS OF OIL, SALT WATER, AND HAZARDOUS MATERIAL SPILLS

4.3.1 SUMMARY

In summary, this section describes the rate, behavior, and potential impacts of spills in a variety of spill scenarios. Spills[1] are not a planned activity for any alternative. Spills are generally unpredictable in cause, location, time, size, duration, and/or material type (Mach et al. 2000). With few exceptions, the occurrence of spills is not dependent upon the alternative chosen, except that the No-Action Alternative (Alternative E) would not result in spills from the ASDP in the Plan area.

Spills of produced fluids, crude or refined oil, salt water, and other chemicals from the proposed five-satellite CPAI Development Plan or from the FFD have a finite rate of occurrence; might affect the environment to varying degrees; and are of concern to all of the stakeholders. The spill scenarios used in this EIS, especially for the larger volume spills, are likely to overestimate, in some cases substantially, the rate or probability of a spill and/or the potential impacts.

For this EIS, the materials that could be spilled are categorized and described as follows:

- Produced Fluids – composed of crude oil, natural gas, brine[2], and formation sand.
- Crude (=Sales) Oil – oil separated from the brine, natural gas, formation sand, and other impurities and then transported to the Trans-Alaska Pipeline and eventually to the Valdez Marine Terminal.
- Refined Oil – Arctic diesel, Jet-A 50 (which is very similar to diesel), unleaded gasoline, hydraulic fluid, transmission oil, lubricating oil and grease, waste oil, mineral oil, and other products.

---

[1] Spills, in various documents, are sometimes referred to as releases, blowouts, uncontrolled releases, leaks, or accidental spills. This EIS uses spills to include all of these terms, as well as any spill that results from sabotage, vandalism, and any other unauthorized release during construction, drilling, production, abandonment, and restoration/rehabilitation of the CPAI Development Plan and FFD.

[2] In this EIS, "brine" refers to the saline water that is part of the produced fluids (in addition to crude oil, natural gas, and formation sand) coming from the oilfields. Brine is commonly also called produced water.

- Salt Water [3]– composed of treated seawater from the Kuparuk Seawater Treatment Plant (STP) at Oliktok Point and brine separated from the produced fluids.
- Seawater – treated seawater from the Kuparuk STP at Oliktok Point.
- Other Hazardous Materials – includes methanol, antifreeze, water soluble chemicals, corrosion inhibitor, scale inhibitor, drag reducing agent, and biocides.

The ADEC Spill Database (Section 4.3.2) also includes spills of Halon, drilling muds, gravel, fresh water, bentonite, and natural gas. Halon is a gas and its use on the North Slope has been discontinued. Natural gas is also a gas that dissipates rapidly in the atmosphere and has little to no impact on the natural resources. Fresh water is a major constituent of the normal habitat and has little to no environmental impact. Gravel spills occur on or adjacent to roads and pads; they are at most a small areal extension of the impacts described for these structures in Section 4A.3.1 through Section 4F.3.1. Drilling muds, including bentonite, are primarily clay and water and most releases are on or adjacent to roads or drilling pads. Like gravel, the impacts are a small areal extension of the impacts described for these structures in Sections 4.3.2.4 Sewage spills are not included in this discussion (Section 4A.2.2.2 through Section 4F.2.2.2) for more information on sewage spills) because they are not considered oil, salt water, or hazardous material; they are not included in the ADEC database (ADEC 2003d); and they are typically small and confined to pads.

The rate, risk, probability, and impacts of oil and hazardous material spills on the North Slope have received extensive analysis and review in several recent EISs, environmental assessments, and other reports. Although the details differ among several of the documents, the basic data and conclusions are generally similar. This EIS incorporates these documents by reference and summarizes the key points. Referenced documents include the following:

- Northwest National Petroleum Reserve-Alaska Draft Integrated Activity Plan/Environmental Impact Statement (BLM and MMS 2003)
- Northeast National Petroleum Reserve-Alaska Final Integrated Activity Plan/Environmental Impact Statement (BLM and MMS 1998a)
- Alaska Outer Continental Shelf, Liberty Development and Production Plan, FEIS (MMS 2002)
- Final Environmental Impact Statement, Beaufort Sea Oil and Gas Development/Northstar Project (USACE Alaska District 1999)
- Final Environmental Impact Statement: Renewal of the Federal Grant for the Trans-Alaska Pipeline Right-of-Way (BLM 2002a)
- Environmental Report for Trans-Alaska Pipeline System Right-of-Way Renewal (TAPS Owners. 2001a)
- Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope (NRC 2003)
- A review of Oil Spill Risk Estimates Based on Current Offshore Development Technologies. NSB-SAC-OR-130 (NSB 2003b)
- Environmental Evaluation Document, Colville River Unit- Satellite Development, Revised June 2002 (CPAI 2002)
- Oil Discharge Prevention and Contingency Plan (ODPCP) April (CPAI 2003)
- Estimation of Oil Spill Risk from Alaska North Slope, Trans-Alaska Pipeline, and Arctic Canada Oil Spill Data Sets (Mach et al, 2000)

[3] For this EIS, salt water is used as a general term to include seawater [described below] unless there is a specific reference to the seawater alone

This section identifies the primary causes and sources of spills and refers back to Section 2 for the construction, drilling, operation, maintenance, abandonment and restoration/rehabilitation procedures, facility design, and CPAI training programs that are designed to mitigate these causes. Section 2 is also referenced for the response plans required by state, federal, and borough agencies and detailed by CPAI in their ODPCP (CPAI 2003f). However, accidental spills will still occur. This section also describes the rate, characteristics, and impacts of those potential spills.

Where appropriate, this EIS considers the impacts of spills that occur during construction[4], drilling, and production/operations activities separately. However, in the first few years of the CPAI Development Plan and longer in the FFD, all of these activities will be occurring simultaneously, usually, but not always, in separate locations. The majority of construction spills tend to be relatively small, and most result from vehicle and construction equipment fueling and maintenance (NRC 2003, Mach et al. 2000). A tanker truck accident or a fuel storage tank failure is the most likely source of the largest construction spills. Spills from pipelines, well blowouts[5], uncontrolled releases, or facility accidents would not occur at a construction site. These latter spills could occur during drilling and production operation phases due to a variety of causes including structural failures and have the potential to result in larger-volume spills.

Spills could occur on and/or from pipelines, production pads (and FFD APFs), airstrips, roads, and bridges. Spills that leave the gravel pads and gravel roadbed could reach one or more of several habitat types including wet and/or dry tundra, tundra ponds and lakes, flowing creeks and rivers, Harrison Bay[6], and potentially the adjacent nearshore Beaufort Sea. Spills could occur anytime in the year. For this impact assessment, the year is divided into four “seasons”: (1) summer ice-free, (1) fall freeze-up, (3) winter ice cover, and (4) spring break-up. In addition, high water events will occur in spring and may occur in fall, depending upon weather conditions, which could also influence the environmental impact of a spill. Also, high wind events could result in higher or lower than normal water levels and/or could affect the areal extent of impact from a high pressure release from a pipeline that sprays into the air.

Spill impact assessment considers what happens when the probability of a spill has reached 1.0; that is, the spill has occurred. Spill impact assessment is subject to numerous uncertainties and unknowns. As in most of the references consulted for this assessment (including those incorporated by previous reference), the following impact assessment is based on prior analyses for the North Slope, collective empirical experience of spill personnel with North Slope spills, other published and technical reports, experience elsewhere, and the professional judgment of a wide variety of experts (including the author of this EIS section) experienced with oil, chemical, and salt water spills.

The rate of oil and salt water spills from the CPAI Development Plan and FFD is likely to be lower than the history of the past 30 years of oil exploration, development, production, and transportation on the North Slope. The combination of more stringent agency regulations, continually improving industry operating practices, and advancements in Best Available Control Technology (BACT) all serve to reduce the probability and size of spills. The 30-year North Slope history shows that the vast majority of the oil, produced fluids, salt water, and other material spills that have occurred have been very small (fewer than 10 gallons) and very few have been greater than 100,000 gallons (NRC 2003, Mach et al. 2000). The history also shows that the probability of these small spills over the life of the project is essentially 1.0; that is, they do and will occur. However, based on the empirical experience of the North Slope oil companies as well as the experience of oil field operations in the contiguous United States, the chance of a very large spill greater than 1,000,000 gallons is extremely low, and even the probability of a very large spill over 100,000 gallons is low. Most spills have been contained on gravel

[4] In the context of oil and other hazardous material spills (e.g., antifreeze), abandonment and restoration/rehabilitation activities are generally similar to construction activities. Most spills will result from vehicle accidents, vehicle refueling and servicing, and storage of fuels for vehicles. Oily residues from cleaning of abandoned pipelines may also be spilled in vehicle accidents and truck rollovers. For this EIS, impacts described for construction activities are generally applicable to abandonment, restoration, and rehabilitation activities.

[5] For this EIS, “well blowout” refers to the uncontrolled release of oil/gas/brine and drilling fluids during the well drilling or well workover phases. Once a well is drilled and the wellhead and surface safety valve are in place, the loss of produced fluids is termed an “uncontrolled release.” For this EIS, it is the loss of fluids (e.g., oil and brine) that are the primary environmental impact concern. The loss of natural gas is a minor environmental issue because it evaporates and disperses quickly, though it may be a safety issue.

[6] For this EIS, Harrison Bay boundary extends east to Oliktok Point, west to Cape Halkett, and north to the line drawn between these two points. The area beyond that is considered the nearshore Beaufort Sea.

pads and roadbeds (NRC 2003). Most of those that have reached the tundra have covered fewer than 5 acres (BLM and MMS 1998b). Upon detection, spills that have occurred were promptly contained and cleaned up as required by state, federal, and borough regulations (NRC 2003). Impacts that have occurred were judged minor, and natural and/or anthropogenic-assisted restoration have generally occurred within a few months to years (NRC 2003).

4.3.2 BACKGROUND FOR OIL, SALT WATER, AND HAZARDOUS MATERIAL SPILLS

4.3.2.1 Introduction

This section presents a general discussion of the impact of potential spills. The section is structured as follows:

- First, a brief history of oil, salt water, and other spills on the North Slope is provided as background (Section 4.3.2.2).
- Second, the spill characteristics and assumptions used to develop the scenarios for spill rate, characteristics, and impact assessment are described (Section 4.3.2.3). These include size, type of material, type or source of the spill, seasons, and location relative to oilfield infrastructure.
- Third, the rate of spills is discussed (Section 4.3.2.4). The impact of a potential spill is based upon the likelihood or rate that a spill would occur and the severity of that spill. This section discusses the rate of spills based upon the industry operating record on the North Slope, probability and risk analyses performed for other North Slope projects, and considerations specific to the CPAI Development Plan and FFD.
- Fourth, the behavior and fate of spilled material is assessed (Section 4.3.2.5). Behavior and fate depend upon the type of material released and the nature of the receiving environment. This section identifies the type of materials that could be spilled and discusses their chemical and physical properties that influence their behavior in the natural environment. This section also provides a general description of the receiving environment, the seasons, and associated conditions that would influence spill behavior and fate.
- Fifth, potential exposure to the spilled material and its effects on the environment are evaluated (Section 4.3.2.6). In many cases, exposure of various habitats would depend upon the spill location. Similarly, effects of exposure would depend upon the habitat and associated plant and animal species exposed.

A more detailed resource-by-resource impact assessment for each of the alternatives and the FFD is provided in Section 4.3.3.3.

4.3.2.2 History of North Slope Spills

The recent NRC report on “Cumulative Environmental Effects of Oil and Gas Activities on Alaska’s North Slope” (NRC 2003) summarizes the history of North Slope oil spills by stating that “Major oil spills have not occurred on the North Slope or adjacent areas as a result of operations [of the oilfields]. … Many small terrestrial spills have occurred in the oilfields, but they have not been frequent or large enough for their effects to have accumulated.” Appendices F and G of the same NRC report provide the most recent detailed analysis of risk, size, type, and general impacts of North Slope oil and salt water spills. These analyses are the basis for the conclusion quoted.

A key conclusion of Maxim and Niebo (2001a, 2001b, 2001c)[7] is that, although oil and salt water spills on the North Slope continue to occur and the total annual volume of oil spilled fluctuates substantially, there is nevertheless a general decreasing trend over a 30-year oil-field operating history in the total volume of oil spilled. This trend occurs despite better reporting of all sizes of spills, especially the small spills, and despite aging of much of the oilfield infrastructure. Maxim and Niebo attribute this trend to improved technology, better engineering design, greater stress on clean operations, and greater awareness on the part of all the oilfield

[7] Maxim and Niebo were the primary contributors to the detailed analysis of oil and brine spill risks as presented in the NRC report Appendices F and G, as well as that presented in the TAPS EA (TAPS Owners 2001a).

personnel. Increasingly stringent federal, state, and borough regulatory requirements for reporting spills, as well as for preparation of response plans and training, also contribute to the declining long-term trend in total spill incidents. Maxim and Niebo do not analyze the trends in the number or size-frequency of spills, especially the smaller volume ones, partly because of the changes in the way spills have been reported over the 30-years-plus record and partly because the important environmental variable, in their opinion, is the volume spilled.

Mach et al. (2000) reviewed several data bases on oil spills that took place on the Alaska North Slope, Arctic Canada, and the Trans-Alaska Pipeline between 1970 and 1999[8]. Their analysis found 126 spills greater than 4,200 gallons, with 111 of them in Alaska. Nine North Slope spills were greater than 21,000 gallons. The researchers found that "… Alaskan oil spills most frequently are associated with highway tank vehicle accidents and operations support facilities, followed by [oil] spills related to construction camps, operations support facilities, and pipelines. [Fewer] Spills [were] associated with oil production processing facilities, oil production wells, pipeline pump stations, and exploration activities…." They also note that "A general check on the fluctuation of the data set indicated spill occurrence to be quite random. There appeared to be little difference in the size of spills associated with the various facilities, … [except that pipelines had larger spills]". The analysis suggests that "...crude oil spills tend to be larger than other types of spills." It was also noted that "…statistical analysis of individual spill volumes [did not indicate any correlation with location], facility type, oil type, affected [environment], and spill cause." Finally, the analysis showed that more large oil spills occurred between 1975 and 1979 (TAPS operation began in mid-1977) and that the rate of spills greater than 4,200 gallons dropped to a more or less constant rate from 1980 on.

A review of the ADEC spill database from January 1, 1995, to August 18, 2003, (provided by Camille Stephens, ADEC, through Ken Taylor, ADNR, in September 2003 and hereafter referenced as ADEC 2003d[9]) for the North Slope shows 3,673 spill records[10] including oil, salt water (composed of brine from produced waters and treated seawater), and other hazardous materials, as well as a few "freshwater" spills. The database is probably a fair representation of the type, size, location, and cause of spills that one might expect from North Slope oilfield operations in the near future. For oil spills (including produced fluids, crude oil, refined products, and lubricants), the ADEC database reflects the trends described by Maxim and Niebo (2001a, 2001b, 2001c). For salt water spills (including treated seawater, produced fluids, and brine), the number and size of spills fluctuated from 1995 through 2001 and has shown a generally decreasing trend since that time.

The 3,673 spill records from the ADEC and annual oil production volumes obtained on April 6, 2004, from the Alaska Department of Revenue (ADR) website (www.tax.state.ak.us/programs/oil/production/historicaldata/prodCYFY.htm#FYCYANS) are distributed on a calendar-year basis as shown in Table 4.3.2-1.

The average number of records by year for spills over the 8.6-year period (January 1995 to August 2003) is approximately 417 with a range of 226 in 1995 to 615 in 2002 (ADEC 2003d). At the current rate, one might expect approximately 282 spills in 2003.

Of the 3,673 spill records in the ADEC database, no spill was greater than 1,000,000 gallons. Only one spill was greater than 100,000 gallons. In March 1997, 994,400 gallons of salt water "spilled" at DS 4 in the Prudhoe Bay Unit when salt water broached to the surface and was completely contained on the pad (B. Smyth, pers. comm. plus excerpts of the Incident Report of the Investigation Team). Additional records show 22 spills greater than 10,000 gallons of which two were crude oil (approximately 38,000 and 30,000 gallons), one was diesel (18,000 gallons), nine were drilling muds (composed of four incidents with six records for one incident), and six were salt water. Four other releases were reported as greater than 10,000 gallons including Halon and natural gas

[8] Mach et al. (2000) did not analyze salt water spills which have been the largest volume spills on the Alaska North Slope.

[9] The database was provided on a CD. This EIS took the database at face value and did not attempt to verify each record, resolve all apparent inconsistencies and conflicts in reporting, classification, etc. The ADEC is aware of the database limitations and is in the process of correcting them (B. Smyth, pers. comm.). For purposes of the analyses contained in this EIS, these limitations and inconsistencies are not expected to result in substantial changes to the results or conclusions though some of the details as well as accuracy and precision of results might change. In any case, the ADEC database is the best information currently available to us and the public.

[10] There are duplicate and even as many as six records for the same incident. According to Luick (ADEC, pers. comm., 2003), this is an artifact of the database structure that occurs when the same incident involves more than one listed substance. The number of replicated incidents is small and does not materially change the discussion provided in this section.

(both gases) and reserve pit gravel. There were 112 records of spills of 1,000 to less than 10,000 gallons, 411 records of spills 100 to less than 1,000 gallons, 912 records of spills 10 to less than 100 gallons, and 2,215 records of spills less than 10 gallons. Of the latter, 498 records (23 percent) were reported as less than or equal to one gallon. By far the majority of spills since 1995 have been very small to small ones.

TABLE 4.3.2-1 ADEC 1995–2003 DATABASE SPILL RECORDS AND ADR ANNUAL OIL PRODUCTION VOLUMES

Year	Number of Spill Records	Annual Cumulative Spill Volume (millions of gallons)[c]	Annual Oil Production (millions of gallons)[d]
1995	226	0.057193	22,329
1996	438	0.086035	21,997
1997	470	1.079037	20,440
1998	442	0.131229	18,493
1999	381	0.097234	16,517
2000	396	0.116010	15,332
2001	505	0.214543	15,235
2002	615	0.148413	15,356
2003	~282[a]	~0.045000[a]	10,154e
TOTAL	~3755[b]	~1.974694[b]	155,853
Average	417	~0.219410	~17,997

Notes:
[a] The database shows 200 records through mid-August 2003; extrapolating that rate to the end of the year approximates 282 records. The database also shows 29,812 gallons spilled through mid-August 2003 and extrapolation to the end of the year approximates 45,000 gallons.
[b] Because of the extrapolation to the end of 2003, the total estimated number of records is greater than the actual number of records in the database and the total amount spilled is larger than the actual amount reported in the database through August 2003.
[c] A few spills are recorded as pounds instead of gallons. For this table, units are assumed to be the same (e.g., 10 gallons of seawater and 10 pounds of drilling mud are counted as 10 units each.
[d] These oil production volumes are from the ADR Tax Division web site (ADR 2003c), using the calendar year data for Alaska North Slope crude oil.
[e] These data were compiled from the ADR website through August 2003 to match with the ADEC spill database that ended in mid-August 2003.

Since March 1998 when APF-1 began operations, the ADEC database (ADEC 2003d) shows 54 records of spills associated with APF-1 through August 8, 2003. This averages approximately 12 spills per year. One salt water spill was reported as 4,998 gallons, three spills of aviation gas or hydraulic fluid were reported at 100 to 1,000 gallons, 19 spills were reported at 10 to less than 100 gallons including diesel, hydraulic fluid and ethylene glycol (antifreeze), and 31 spills were reported at less than 10 gallons of various materials. Most of these spills were on pads or roads and were associated with routine operations. They were generally the result of human error or equipment failure. According to the CPAI ODPCP (CPAI 2003), while the underground Colville River pipeline crossing was being drilled, one spill of drilling mud in March 1999 did not leave the ice pad; it was not related to oil well drilling. Three spills (100, 210, and 252 gallons) of oil or diesel did reach the tundra. All spills were reported and cleaned up.

There have been no blowouts or uncontrolled releases of produced fluids at APF pads since drilling was initiated (CPAI 2003).

North Slope-wide, Fairweather (2000) (quoted in Appendix F, NRC 2003) reported five events from 1971 to 2001 that resulted in uncontrolled surface release of liquids or gas from the boring. None of these events resulted in oil spills (Mallary 1998). Over this same period, approximately 5,000 wells were drilled or re-drilled, giving a rate of approximately one event per 1,000 wells drilled or a probability of approximately 0.001, about the same as for other areas (Mallary 1998, S.L. Ross 1998). The conclusion is that blowouts and uncontrolled releases have been rare events and are likely to be even rarer in the future as BACT is applied to future drilling and production activities.

4.3.2.3 Basic Assumptions for Spill Impact Assessments

The discussion of the impacts of spills requires description of the several basic assumptions and classifications related to the spills themselves and to the environmental variables that might affect the spill impacts. These descriptions are provided with the caveat that they are necessarily simplified and might not represent the entire spectrum of possible values or combinations of values and events that might be realized in actual spills. However, many of these assumptions have been used in previous assessments and all are based on the empirical experience of oil spill experts on the Alaska North Slope and elsewhere.

SPILL SIZE CLASSIFICATION

To describe the impacts of spills in this EIS, spills were categorized as:

- Very small spills – less than 10 gallons (approximately 0.25 barrels[11] or bbl)
- Small spills – 10 to 99.5[12] gallons
- Medium spills – 100 to 999.5 gallons
- Large spills – 1,000 to 100,000 gallons
- Very large spills – greater than 100,000 gallons.

This size classification is similar to the unofficial "rule of thumb" used by the ADEC when they respond to and evaluate spills of oil and hazardous materials (B. Smyth 2003, pers. comm.). The very small spill and very large spill categories were added to facilitate discussion of the majority of spills (less than 10 gallons) and of the very rare spills (greater than 100,000 gallons); the latter are discussed in more detail in Section 4.3.4.

TYPES OF MATERIALS SPILLED

For this EIS, the potentially spilled materials are categorized and described as follows:

- Produced Fluids – composed of crude oil, natural gas, brine, and formation sand. (Note that the crude oil in produced fluids from the CPAI Development Plan and probably FFD is generally lighter, has more volatiles, and is sweeter than several other North Slope crude oils including Endicott, Milne Point, and North Star (Leirvik et al. 2002). Also, formation pressures in the Alpine fields are less than fields to the east.)
- Crude (=Sales[13]) Oil (from FFD only) – oil separated from the brine, natural gas, formation sand, and other impurities and then transported to the Trans-Alaska Pipeline and eventually to the Valdez Marine Terminal.
- Refined Oil – includes Arctic diesel, Jet-A 50 (which is very similar to diesel), unleaded gasoline, hydraulic fluid, lubricating oil and grease, transmission oil, waste oil, mineral oil, and other products.
- Salt Water – composed of treated seawater from the Kuparuk STP at Oliktok Point and brine separated from the produced fluids. (For this EIS, salt water is used as a general term to include seawater, brine in produced fluids, and other saline solutions unless there is a specific reference to the seawater alone).
- Seawater – specifically the treated seawater from the Kuparuk STP at Oliktok Point.
- Other Hazardous Materials – includes methanol, antifreeze (tetraethylene glycol or TEG), water soluble chemicals, corrosion inhibitor, scale inhibitor, drag reducing agent (e.g., Dra Flo XL) , and biocides[14.]

---

[11] One barrel contains 42 gallons. Gallons are used throughout this section.

[12] Any spill of 99.5 – 99.9 gallons is considered a 100 gallon spill, i.e., spill volume is rounded to the nearest gallon.

[13] Sales Oil is the crude oil from the produced fluids with the brine, grit, natural gas, and other impurities removed before the crude oil is transported to the Trans-Alaska Pipeline and eventually to the Valdez Marine Terminal.

The ADEC Spill Database also includes spills of Halon, drilling muds, gravel, fresh water, bentonite, and natural gas. Halon is a gas and its use on the North Slope has been discontinued. Natural gas is also a gas that dissipates rapidly in the atmosphere and has little to no impact on the natural resources. Fresh water is a major constituent of the normal habitat and has little to no environmental impact. Gravel spills occur on or adjacent to roads and pads; they are at most a small areal extension of the impacts described for these structures in Section 4A.3.1 through Section 4F.3.1 Drilling muds, including bentonite, are primarily clay and water and most releases are on or adjacent to roads or drilling pads. Like gravel, the impacts are a small areal extension of the impacts described for these structures in Section 1.3.2.4.

The impact assessment is based primarily on spills of produced fluids (sometimes referred to as crude oil spills in some of the North Slope literature), refined products (primarily diesel and hydraulic oil), and salt water. These materials are the most likely to spill in sufficient volume and frequency at locations where the spilled material could reach the natural environment and could result in impacts to that environment and its resources. Hence, most of the data on spills on the North Slope (and elsewhere) are on "oil" spills and, to a lesser extent, on salt water spills.

PHASE OF OILFIELD DEVELOPMENT

Where appropriate, this EIS considers potential spill impacts associated with the construction, drilling, production, operation, abandonment, and restoration/rehabilitation phases[15] of the oilfield development separately. This is relevant because some sources and sizes of spills would not occur in some phases or would more likely occur in one phase than another. For example, during construction, most of the spills would be relatively small, consist of diesel, hydraulic fluid, antifreeze, lubricating oils, and similar materials associated with the vehicles and construction equipment on site or in transit to and from the site (NRC 2003, Mach et al. 2000). Once construction and drilling are completed, the likelihood of spills and leaks from vehicles and heavy equipment would be reduced because vehicle and equipment activity would be reduced during production and operations relative to construction and drilling, and the volumes of refined products and most chemicals being transported are reduced. In addition, blowouts would not occur during construction and, if they were to occur at all, would occur during the drilling phase. Uncontrolled releases could occur during exploration and development drilling. Spills of produced fluids and salt water would only occur during the production phase.

SEASONS

The season in which a spill occurs might dramatically influence its behavior, impacts, and the cleanup response actions. This EIS considers spills in four seasons.

Summer (Ice-Free)

Summer is confined to the ice-free period when most of the rivers and creeks are flowing; ponds, lakes, and Harrison Bay are open water; tundra is snow-free; and biological use of tundra and water bodies is high. Currents, winds, and passive spreading forces would disperse spills that reach the water bodies. Spills to tundra would directly affect the vegetation, although the dispersal of the spilled material is likely to be impeded by the vegetation. Spills to wet tundra may float on the water or be dispersed over a larger area than would spills to dry tundra or to snow-covered tundra. Spills under pressure that spray into the air may be distributed downwind over substantial areas and impact the tundra vegetation and water bodies.

---

[14] Sewage spills are not included in this section but they are considered in the anlyses of impacts to the different resources. They are not included in the ADEC database because they do not constitute a hazardous substance, oil, or salt water. Most sewage spills are small and occur at the facilities on the gravel pads. Also, sewage is discharged under an NPDES permit and, by regulation to meet applicable water quality standards, typically does not contain hazardous substances above specified limits.

[15] Refer to footnote 3.

Fall (Freeze-Up)

Freeze-up is the period when the water bodies are beginning to ice over but the ice cover might come and go depending upon temperature, wind, currents, and river flow velocities. Snow begins to cover the tundra and most of the migratory birds are leaving the North Slope. Spilled material could be dispersed when it reaches flowing water but slowed or stopped when it reaches snow or surface ice. The spilled material could be contained by the snow or ice but dispersed if this ice breaks up and moves before it re-freezes. The spilled material also could flow into ice cracks to the underlying water where it could collect.

Winter (Ice Cover)

Winter is the long, dark period when water bodies including Harrison Bay and the Colville River are covered with mostly unbroken ice, and snow covers the tundra. Dispersal of material spilled to the tundra generally would be slowed though not necessarily stopped by the snow cover. Depending upon the depth of snow cover as well as temperature and volume of spilled material, it may reach the underlying dormant vegetation or tundra ponds and lakes. Similarly, spills to rivers and creeks generally would be restricted in areal distribution by the snow and ice covering the water body, compared to seasons when there is little or no snow and ice cover. Spills under the ice to creeks, rivers, and tundra ponds/lakes might disperse slowly as the currents are generally slow to non-existent in the winter.

Spring (Break-Up)

Break-up is the short period in the spring when thawing begins in the higher foothills of the Brooks Range and river flows increase substantially and quickly, often to flood stages. These increased flows cause the river ice cover to break up and flow downriver, eventually to Harrison Bay. The river floodwaters usually flow over the sea ice of Harrison Bay, which hastens the break-up of the sea ice. Snow cover begins to melt off the tundra and many of the migratory species, especially birds, return to the tundra. Spills to water bodies during break-up are likely to be widely dispersed and difficult to contain or clean up. Spills to the tundra might be widely dispersed if the flooding overtops the river and creek banks, and entrains the spilled material.

WEATHER, WINDS, AND WATER LEVEL

Weather, especially rapid warming periods and/or heavy rainfall, may cause snowmelt and/or runoff that could result in flooding of the tundra lakes/ponds, major creeks and the Colville River Delta channels. If spilled material is released to the flooded area, especially to flowing waters, the material could be distributed to adjacent terrestrial and tundra pond/lake habitats that are normally not exposed. The habitats and natural resources as well as human uses of the habitats and resources may be exposed to the spilled material.

High wind velocity may result in widespread distribution of any material released under pressure, primarily from pipelines or blowouts and uncontrolled releases. The material would spray out and become a cloud of mist and fine particles that would be carried downwind. The extent of the distribution will depend upon wind velocity and the direction of the released spray (e.g., downward into the tundra, horizontal, or skyward).

Water levels in the Colville River Delta as well as Harrison Bay may increase or decrease substantially over normal flow and tidal levels, depending upon the duration and strength of wind storms. A spill occurring at high water levels may have distribution and impacts similar to that occurring from flooding described above.

LOCATION OF SPILLS

Most spills would occur on or in close association with the oilfield infrastructure. For convenience, the locations are classified as follows:

- Gravel pads for drilling, production and processing facilities
- Gravel roads (including culverts)
- Gravel airstrips
- Temporary ice roads and ice pads
- Pipelines
- Bridges

Most spills, except from pipelines, would occur and be contained on or immediately adjacent to the ice or gravel pads, roads, and airstrips, and they would be promptly cleaned up as required by federal, state, and borough regulations before they reach the tundra or water bodies. Some spills from vehicles, including fuel and other tank trucks running off the roads, may result in much or all of a load being spilled to the tundra, tundra ponds and lakes, or flowing water bodies adjacent to the road or pad.

Most pipeline spills will occur at some distance from the nearest road or pad, especially in Alternative D and B, and for CD-1 to CD-3 pipeline route for Alternatives A, B, D, and F. Much less likely are spills from other sources (e.g., aircraft crash) that would occur any substantial distance from one of these structures. Also, material released under pressure from a pipeline during high wind events could result in the spilled material being blown over a wide area of tundra, often remote from access roads.

POTENTIAL SOURCES OF SPILLED MATERIAL

The main sources of spilled material from the proposed CPAI Development Plan facilities would include the following:

- Alpine production pads CD-3 through CD-7 would include storage tanks and containers, gas and salt water injection facilities, and produced fluids pumping facilities. The size, contents, and secondary containment for the storage tanks and containers at the drilling and production pads (and HPF-1 and HPF-2 in the FFD) are described in Sections 2.3.3.1 and 2.2.12.3. Because of the secondary containment around the storage tanks and containers, it is very unlikely that catastrophic failure of one or more storage tanks could be a potential source of a spill large enough to leave the pad. However, as a worst-case scenario in the ODPCP (CPAI 2003), such a spill is considered possible if the secondary containment were breached. Processing facilities also store chemicals such as methanol and antifreeze.
- In-field pipelines for produced fluids, diesel, and salt water connect the various production pads to the process facilities at APF-1. The produced fluids pipeline would contain crude oil, natural gas, and produced water. The salt water pipelines would contain either treated seawater or a blend of treated seawater and brine from the produced fluids. The products pipeline would be used to distribute various types of diesel to the CD-3 production pad in Alternative A. The MI pipelines would contain light hydrocarbon fluid that may have a range of liquid to gas content. If released, the gaseous component would dissipate in the atmosphere and would not cause impact to natural resources except for the potential for a fire that could subsequently damage an adjacent pipeline and cause a release of another material. The liquid component of the MI would be sprayed under pressure as a mist and may impact resources and habitat downwind of the source. The lift gas pipeline would transport natural gas from the central processing facility to the production pads for use as fuel gas and/or to lift produced fluids in the well bore.

- Vehicles including light- and heavy-duty trucks and tank trucks, aircraft (fixed-wing and rotary), watercraft, snow machines, and heavy equipment might spill or leak fuels (diesel, gasoline, jet), oils (motor, transmission, hydraulic), and antifreeze from unintentional releases during refueling and maintenance, leaks and drips during normal operations, or releases related to vehicle or equipment accidents. With the exception of vehicles leaving the pads or roads (e.g., tanker rollover, vehicle accident), impacts from these types of spills generally would be confined to small areas on airstrips, ice pads, and gravel roads or gravel pads where containment and cleanup could be easily accomplished. Spills from snowmobiles might occur on the tundra remote from roads and pads, but the volumes would be small and the snow would generally contain it. Spills from watercraft also would be relatively small.

The main sources of spilled material from the hypothetical FFD facilities include all the sources listed above for the CPAI Development Plan and a potential additional salt water pipeline and sales oil pipeline, if new processing facilities are developed along with associated production pads and pipelines. In the FFD, the extended Sales Oil and treated salt water pipelines would extend from CD-1 to HPF-1 and HPF-2 if they were built (Section 2.3.2). An FFD sales oil pipeline from National Petroleum Reserve-Alaska would not necessarily connect to the existing sales oil line between KRU and APF-1. The connection would depend upon the production rates of the FFD processing facilities and the capacity of the existing Alpine sales oil line at the time. In the complete development of the FFD, the additional FFD pipelines would cross at least five major rivers (i.e., Kalikpik River, Fish-Judy Creeks, Ublutuoch River, and the Nigliq Channel). The FFD Sales Oil pipeline would contain at least 10 vertical loops, one on each side of these rivers (Section 2.3.2 for further details).

Well blowouts and uncontrolled releases are an additional but low-probability potential source of spilled production fluids (NRC 2003). Blowouts could occur during well drilling and uncontrolled releases could occur during production activities including workover operations. A well blowout could result in a potentially large to very large volume spill of produced fluids (crude oil and brine) over an extended period. Fluids released by a well blowout or uncontrolled release could extend beyond the limits of the gravel production pad anywhere in the Plan Area under the proposed CPAI Development Plan or FFD and could potentially reach nearby ponds, lakes, creeks, and/or rivers with a potential to enter the marine environment in Harrison Bay.

4.3.2.4 Rate of Spills

The likelihood of a spill is determined based upon the rate or frequency of occurrence. The rate of occurrence is a function of several factors including age of the infrastructure, operating procedures, personnel training and awareness, maintenance, and human error. Impact analyses typically are presented in various scenarios to span the range of rate or probability of occurrence. Rate is expressed in several ways; for example, “once in 1,000 years,” “once in one billion barrels (or gallons) of oil produced,” or “once per 10,000 wells drilled.” This EIS analyzes the potential impacts of a range of possible spills including the very low likelihood, very large volume spills. This section presents a general discussion of rate or probability of spills associated with North Slope oilfield construction, drilling, and production, and includes discussion of the more likely spills, mostly very small to small ones. The very low likelihood, very large volume spills (VLVS) and their impacts are discussed separately and in more detail in Section 4.3.4.

RATE OF VARIOUS SIZES AND TYPES OF SPILLS

A review of the several EISs and similar documents referenced in Section 4.3.1 indicates that the probability of very small, small, and even medium size spills is relatively high, with the probability of very small and small spills being 1.0 over the life of the CPAI Development Plan and/or the FFD, i.e., they will occur. The probability of large spills is substantially less, i.e., there will be fewer large spills, but there is likely to be at least one and probably more over the life of the projects. Finally, based on past experience on the North Slope, the probability of a very large spill is very low and might approach 0.0 as the size of the potential spill increases. The qualitative assessment of potential rate of occurrence is provided in Table 4.3.2-2. The relative ranks are based on: the experience of several personnel with extensive oil spill background with spills, peer-reviewed and “gray” literature, USCG spill reports; the reports incorporated by reference earlier; and other spill reports for North Slope incidents. The assessment is a subjective evaluation and the categories are relative to each other in the context of North Slope oil field operations.

The rest of this section provides the background information for the potential rate of occurrence of various size spills. The rate is based on rate, probability, and risk analyses prepared for other EISs and reports that are incorporated earlier by reference, and by the size and proportion of spills that are recorded in the ADEC database for North Slope spills from January 1995 to August 2003. The relevant information from the ADEC database (ADEC 2003d) is summarized in Table 4.3.2-3.

For this EIS, the rate of each type of material spill, regardless of the volume, may be estimated using the ADEC 1995 to 2003 spill database and the ADR data on oil throughput since 1995. The rates are shown in Table 4.3.2.2 and are expressed as rate of occurrence of a spill of each category of material per billion gallons of oil transported from Pump Station 1. The rates range from less than 0.1 (less than one in 10 billion gallons of oil transported) to 5.3 (approximately one in 0.19 billion or 190 million gallons of oil).

CRUDE OIL

For this analysis, the "crude oil" category includes oil in the produced fluids (which also contain brine that would likely be spilled at the same time), as well as the Sales Oil Pipeline (FFD only).

In the Northeast National Petroleum Reserve-Alaska IAP/EIS (BLM and MMS 1998b) and based on data for spills on the North Slope from January 1989 to December 1996, the BLM estimated the average crude oil spill at approximately 160 gallons and the median size at approximately 7 gallons. The size range was 1 gallon to 38,850 gallons. Approximately 99 percent of the spills were less than 1,050 gallons and no oil spill was greater than 42,000 gallons. For the Northeast National Petroleum Reserve-Alaska IAP/EIS, the BLM assumed the average crude oil spill was 168 gallons (4 bbls). They also assumed that a very large spill (using the BLM spill size categories) from a pipeline was 117,600 gallons (2,800 bbls) spilled over a 30-day period.

In the Northwest National Petroleum Reserve-Alaska Draft IAP/EIS (BLM and MMS 1998), and based on data for spills on the North Slope from January 1989 to December 2000, the BLM estimated the average crude oil spill at approximately 113 gallons and the median size at approximately 5 gallons. The size range was 1 gallon to 38,850 gallons. Approximately 99 percent of the spills were less than 2,520 gallons and, again, no spill was greater than 42,000 gallons. For the Northwest National Petroleum Reserve-Alaska Draft IAP/EIS, the BLM assumed the average small crude oil spill was 126 gallons. The BLM also assumed that the large crude oil spill was 21,000 gallons from a pipeline spill.

Mach et al. (2000) estimated the rate of oil spills (including crude oil spills) to range from 0.0053 +/-.24 percent spills per 42,000,000 gallons of crude oil produced for a spill of less than 4,200 gallons (a large spill as defined in this EIS) to 0.000078 +/-200 percent spills per 42,000,000 gallons of crude oil produced (a very large spill as defined in this EIS). They did not provide spill rate estimates for very small to medium spills.

The CRU Satellite Development Environmental Evaluation Document (EED) (PAI 2002a), and the Liberty EIS (BLM and MMS 2002) report ranges of values for the small and large spills of crude oil that are similar to, or the same as, those in the National Petroleum Reserve-Alaska EISs cited above and incorporated by reference.

TABLE 4.3.2-2 RELATIVE RATE OF OCCURRENCE FOR SPILLS FROM MAIN SOURCES

	Spill Size				
Source Pipeline	**Very Small (<10 gal)**	**Small (10–99.5 gals)**	**Medium (100–999.5 gal)**	**Large (1,000–100,000 gals)**	**Very Large (>100,000 gals)**
Produced Fluids	H	H	M	L	VL
Salt Water	H	H	M	L	VL
Diesel	H	M	L	VL	0
Sales Oil (FFD only)	M	M	M	L	VL
Bulk Storage tanks & containers on pads	L	L	L	VL	0
Tank vehicles	H	M	L	VL	0
Vehicle & Equipment Operation and Maintenance	VH	VH	M	VL	0
Other Routine Operations	VH	VH	H	L	VL
Drilling Blowout	VL	VL	VL	VL	VL
Production Uncontrolled Release	VL	VL	VL	VL	VL

Notes:
VL = Very Low rate of occurrence (approaching 0.0) L = Low rate
M = Medium rate H = High rate
VH = Very High rate (approaching 1.0) 0 = will not occur

TABLE 4.3.2-3 TYPE, NUMBER, SIZE, PERCENTAGE, AND RATE OF SPILLS IN ADEC 1995 TO 2003 NORTH SLOPE DATABASE

Material	No. Records[a]	Size (gal) of Largest Spill	% of All Records [b]	Spill Rate per billion gallons oil transported in TAPS[e]
Crude Oil	422	38,000	11.5	2.7
Diesel	820	10,000	22.3	5.3
Hydraulic Oil	630	660	17.2	4.0
Engine Lube	178	650	4.8	1.1
Transmission Oil	39	75	1.1	0.3
Waste Oil	13	1,500	0.4	<0.1
Gasoline	19	100	0.5	<0.1
Other Refined Products[c]	48	5,700	1.3	0.2
Salt Water	121	994,400	3.3	0.8
Produced Water	172	92,400	4.7	1.1
Propylene/Ethylene Glycol	268	5,700	7.3	1.7
Drilling Muds	207	20,000	5.6	1.3
Methanol	197	2,520	5.4	1.3
Others[d]	539	30,000	14.7	3.6

Notes:
[a] Number of records in the January 1995 to August 2003 ADEC database (ADEC 2003 d).
[b] Based on total number of records for each material out of the total of 3,673 spill records in the ADEC 1995–2003 database
[c] Includes asphalt, aviation fuel, grease, kerosene, synthetic oil, transformer oil, and turbine fuel.
[d] Includes Halon (a gas no longer used on North Slope), corrosion inhibitors, drag reducing agents, chemicals, acids, alcohols, natural gas, therminal, water, unknown, and “others” (of which about 70 could be identified as salt water of some type).
[e] For the 1995 to 2003 period of the ADEC database, approximately 156,000,000,000 gallons of oil were transported. The rate in column 5 is based on dividing the number of records (column 2) by 156.

The ADEC North Slope spill database (ADEC 2003d), for the period of January 1995 through August 2003, includes 3,673 records. The two largest of the 422 crude oil spill records were 38,000 and 30,000 gallons. Using the size categories described earlier in this EIS (Section 4.3.2.3) and Table 4.3.2-2, there were 10 other large spills, 67 medium spills, 145 small spills, and 196 very small spills. Some of the reported crude oil spills could be associated with produced fluids or produced water, making it impractical to determine how much of the spilled material was actually oil.

The largest oil spill reported by CPAI (CPAI 2003) was 275 gallons at CD-1 Pad.

For the analysis of the CPAI Development Plan and the FFD, it is assumed that:

- The probability of very small and small spills is 1.0 and the size of these spills is 5 and 60 gallons, respectively. These l spill volumes are an arbitrary designation of the midpoint in the spill volume range (e.g.., less than 1 gallon to less than 10 gallons). Based on the ADEC database, the proportion of these very small and small oil spills is approximately 9.3 percent[16] of all the spill records since 1995.
- The rate of medium spills (i.e., 100 to 999.5 gallons) is approximately 1.8 percent based on the ADEC database.
- The size of a large spill is between 1,000 and 100,000 gallons, which includes the value of 38,850 gallons used in the Northeast National Petroleum Reserve-Alaska IAP/EIS (BLM and MMS 1998a). This value is close to the two largest crude oil spills reported in the ADEC database since 1995 (see above). The rate of a large spill is 0.3 percent; 12 out of 3,673 records for the entire database. The rate of the two largest crude oil spills is 0.05 percent.

The actual amount of crude oil in the reported volumes for crude oil spills in the ADEC database might be an overestimate in some cases because the spills could have been produced fluids of which part of the volume spilled was salt water.

REFINED HYDROCARBONS

For this analysis, the "refined hydrocarbon" category includes Arctic diesel, Jet A-50, hydraulic oil, lube oil and grease, transmission oil, waste oil, unleaded gasoline, mineral oil, and other refined products. The number of records, maximum size, and percentages that each of these spill types constitute of all spills on the North Slope since 1995 are shown in Table 4.3.2-3.

The average spill size has been estimated at 29 gallons (BLM and MMS 1998b; BLM and MMS 2003; PAI 2002a) and diesel spills account for most of the spills in frequency and total volume (BLM 2003b). Of the 820 diesel spills listed in the ADEC database (ADEC 2003d), 18 were large (greater than 1,000 gallons) with the largest at 10,000 gallons; 70 were medium (100 to 999.5 gallons), 272 were small (10 to 99.5 gallons) and 460 were very small (less than 10 gallons).

Hydraulic oil, engine lube oil, and transmission oil spills, though relatively numerous (847 or 23 percent out of 3,673 records) are generally small (maximum reported size was 660 gallons) and confined to the pads. Gasoline spills are small and infrequent because diesel is the most prevalent equipment fuel. Waste oil and "Other Refined Products" also are relatively infrequent (51 or 1.4 percent of 3,673 records) and most are very small and small spills, with one medium spill.

Because these spills are small, unpredictable in time and location, mostly occur on gravel pads or roadways, and cannot spread far, the impacts are not anticipated to be cumulative. Therefore, they are evaluated as individual spills of approximately 100 gallons each.

In the Northwest National Petroleum Reserve-Alaska Draft IAP/EIS (BLM and MMS 2003), the BLM assumed that a large spill of diesel from an onshore bulk storage tank would be 37,800 gallons. Based on the project description for the CPAI Development Plan and the FFD, and assuming that the entire contents of the storage tank could be spilled onto the environment (that is, the secondary containment fails completely), the maximum spill of diesel could be 4,200 gallons at any production pad and 15,000 gallons for the FFD processing facilities (Section 2.). For the analysis of the CPAI Development Plan and the FFD, a large diesel spill is assumed to be 15,000 gallons.

---

[16] As an example, calculated as (146 + 197/3,673) 100 percent = 9.3 percent.

SALT WATER

Data and/or analyses of the existing data is limited concerning frequency, location, volume, or causes of salt water spills, whether it is seawater from the STP, brine in the produced fluids, or the blended brine and seawater that is re-injected into the oilfield. The risk of salt water spills from pipelines generally can be addressed by the same approach as produced fluids. Qualitatively, the likelihood of a salt water spill is similar to the likelihood of a produced fluids spill because the lines are collocated, the materials transported have approximately the same corrosivity, and the other causes of pipeline leaks are human or mechanical in nature. The produced fluids pipelines are also subject to internal erosion from the formation sands.

The ADEC database for spills on the North Slope from 1995 to 2003 (ADEC 2003d) shows 121 salt water and 172 produced water spills (approximately 8.0 percent of all spill records) with the largest spills being 994,400 and 92,400 gallons, respectively. Most were very small (40 incidents) to small (49) spills[17.]

OTHER MATERIALS

Other spilled materials in the records of the ADEC database (ADEC 2003d) include drilling muds, methanol, propylene and ethylene glycol (antifreeze), Halon, corrosion inhibitors, drag reducing agents, other chemicals, acids, source water, unknown, and "other." These account for approximately 558 or 15.2 percent of the records. A few large spills have occurred of some of these materials (e.g., drilling muds at 18,900 gallons, ethylene glycol at 5,700 gallons, drag reducing agent at 6,000 gallons) but most of the spills have been small or very small. Most of these spills were contained on and cleaned up at the pad or road where they occurred.

The rate of a spill of one of the "Other Materials" is relatively high (approximately 15 percent of all spills) but the volumes are relatively low and most occur on pads or roads.

4.3.2.5 Behavior and Fate of Spilled Materials

This section describes primarily the properties and behaviors of spilled oil that are important to the evaluation of the potential effects that the spilled oil might have in the various environments in the Plan Area. Much of this section is excerpted from the Northwest National Petroleum Reserve-Alaska Draft IAP/EIS, which is incorporated by reference (BLM and MMS 2003). The focus is spilled oil, broadly defined to include crude oil, produced fluids, and refined products. Because the impacts are likely to be greater and more persistent from oil than from most other spilled materials (except possibly salt water), there are more data and analyses available, and most, though not all, stakeholders are generally more concerned about oil spills than about salt water or other chemical spills.

Salt water might behave generally like oil when it is spilled in large volumes, although salt water usually would be less viscous, especially in the warmer break-up and ice-free seasons, and could therefore spread farther than the same amount of oil might. If spilled into freshwater bodies, the salt water would be completely miscible and the salt concentration would be diluted in the fresh water. The amount of dilution depends primarily on the relative volume of the receiving water and the spilled salt water, as well as the dynamics of the receiving water body. For example, a spill into the Nigliq Channel at spring break-up flood stage might be diluted very rapidly, whereas a salt water spill to a small tundra lake on a calm summer day may remain at relatively high salinity for some time.

Materials such as methanol and ethylene glycol are completely miscible in water, and others, such as acids and some chemicals, are completely soluble in water. Because they are miscible or soluble, it is generally not practical to contain or clean up these materials before they are dispersed and diluted in the water or atmosphere. They may also be toxic until they are substantially diluted or neutralized.

---

[17] The "Other" category in the ADEC database includes 303 incidents of which at least 70 are described in explanatory notes as being partially or all salt water. Numerous spills of KCl solutions and other salt solutions are also included in the "Other" category. For this analysis, the incidents listed as "Other" are not assigned to one of the more specific categories in the ADEC database. Were this to be done, the details of some of the results presented herein might change but the general conclusions would not.

FACTORS AFFECTING THE FATE AND BEHAVIOR OF SPILLED OIL

The primary and shorter-term processes that affect the fate of spilled oil are spreading, evaporation, dispersion, dissolution, and emulsification (Payne et al. 1987, Boehm 1987, Boehm et al.1987, Lehr 2001, Leirvik et al. 2001). These processes are called weathering. Weathering dominates during the first few days to weeks of a spill. A number of longer-term processes also occur, including photo- and biodegradation, auto-oxidation, and sedimentation. These longer-term processes are more important in the later stages of weathering and usually determine the ultimate fate of the spilled oil.

The chemical and physical composition of oil changes with weathering. Some oils weather rapidly and undergo extensive changes in character, whereas others remain relatively unchanged over long periods of time. As a result of evaporation, the effects of weathering are generally rapid (one to a few days) for hydrocarbons with lower molecular weights (e.g., gasoline, aviation gas, and diesel). Degradation of the higher-weight fractions (e.g., crude oil, transmission and lube oil, hydraulic fluid) is slower and occurs primarily through microbial degradation and chemical oxidation. The weathering or fate of spilled oil depends on the oil properties and on environmental conditions, both of which can change over time.

Spreading

Spreading reduces the bulk quantity of oil present in the vicinity of the spill but increases the spatial area over which adverse effects could occur. Thus, oil in flowing systems (e.g., rivers and creeks, Harrison Bay) rather than contained systems (e.g., tundra ponds and lakes) would be less concentrated in any given location, but could cause impacts, albeit reduced in intensity, over a larger area. Spreading and thinning of spilled oil also increases the surface area of the slick, enhancing surface-dependent fate processes such as evaporation, bio- and photodegradation, and dissolution.

Evaporation

Evaporation is the primary mechanism for loss of low-molecular-weight constituents and light oil products. As lighter components evaporate, the remaining petroleum hydrocarbons become denser and more viscous. Evaporation tends to reduce oil toxicity but enhance persistence. Hydrocarbons that volatilize into the atmosphere are broken down by sunlight into smaller compounds. This process, referred to as photodegradation, occurs rapidly in air, and the rate of photodegradation decreases as molecular weight increases. Alpine crude oil from the current production field tends to have a greater proportion of constituents that evaporate rapidly compared to Endicott, Milne Point Unit, or North Star crude oils (Leirvik et al. 2001).

Dispersion

Dispersion of oil increases when water surface turbulence increases. Wind, gravity or tidal currents, or broken ice movement could cause the turbulence. The dispersion of oil into water increases the surface area of oil susceptible to dissolution and degradation processes and thereby limits the potential for physical impacts. However, some of the oil could become dispersed in the water column and/or on the bottom as it adheres to particulate matter suspended in the water column. The presence of particulates including organic matter, silt and clay, and larger sediment particles is likely to be greatest during break-up, flood flows, and wind storms (especially in Harrison Bay).

Dissolution

Dissolution[18] of oil in water is not the primary process controlling the fate of the oil in the environment; i.e., oil generally floats on rather than dissolves in water. However, to the extent dissolution does occur, it is one of the primary processes affecting the toxic effects of a spill, especially in confined water bodies. Dissolution increases with (1) decreasing hydrocarbon molecular weight, (2) increasing water temperature, (3) decreasing

[18] In this case, the definition of "dissolution" is to dissolve into water.

salinity, and (4) increasing concentration of dissolved organic matter. Components of gasoline (e.g., benzene, toluene, ethylbenzene, and xylenes) would dissolve more readily than the heavier fractions of crude oil or fuel oils under the same environmental conditions.

Emulsification

Emulsification is the incorporation of water into oil and is the opposite of dispersion. Small drops of water become surrounded by oil. External energy from wave or strong current action is needed to emulsify oil. In general, heavier oils emulsify more readily than lighter oils. The oil could remain in a slick, which could contain as much as 70 percent water by weight and could have a viscosity of a hundred to a thousand times greater than the original oil. Water-in-oil emulsions often are referred to as "mousse."

Photodegradation

Photodegradation of oil increases with greater solar intensity. It can be a substantial factor controlling the disappearance of a slick, especially of lighter products and constituents, but it would be less important during cloudy days and could be nonexistent in winter months on the North Slope. Photodegraded petroleum product constituents tend to be more soluble and more toxic than parent compounds. Extensive photodegradation, like dissolution, could thus increase the biological impacts of a spill event.

Biodegradation

Biodegradation of oil by native microorganisms, in the immediate aftermath of a spill, would not tend to be a major process controlling the fate of oil in water bodies previously unexposed to oil. Although oil-degrading microbial populations are ubiquitous at low densities, including on the North Slope, a sufficiently large population must become established before biodegradation can proceed at any appreciable rate.

SUMMARY

Overall, the environmental fate of released oil is controlled by many factors, and persistence cannot be predicted with great accuracy. Major factors affecting the environmental fate include the type of product, spill volume, spill rate, temperature of the oil, terrain, receiving environment, time of year, and weather. Crude oil would weather differently than diesel or refined products in that both diesel and refined products would evaporate at a faster rate than crude oil. Most of the studies on North Slope crude oils have been done with Prudhoe Bay, Kuparuk or Endicott oil, which are heavier than Alpine crude oil (Leivrik et al. 2001). The Alpine crude oil may lose volatile fractions rapidly but still have a high enough pour point to flow under conditions in which the other three oils would not flow over the terrain.

The characteristics of the receiving environment, such as type of land, the surface gradient, marine or fresh water, spring ice overflow, summer open water, winter under ice, or winter broken ice, would affect how the spill behaves. In ice-covered waters, many of the same weathering processes are in effect as with open water; however, the ice changes the rates and relative importance of these processes (Payne et al. 1991).

The time of year when a spill occurs has a major effect on the fate of the crude oil. The time of year controls climatic factors such as temperature of the air, water, or soil; depth of snow cover; whether there is ice or open water; and the depth of the active layer. During winter, the air temperature can be so cold as to modify the viscosity of the oil so it would spread less and could even solidify. The lower the ambient temperature, the less crude oil evaporates. Both Prudhoe Bay and Endicott crudes have experimentally followed this pattern (Fingas 1996). Frozen ground would limit the depth of penetration of any spill.

FATE AND BEHAVIOR OF SPILLS ON TUNDRA

Movement of spills of oil and salt water over the ground surface follows the topography of the land. In general, a spill will flow until: (1) it reaches a surface water body or a depression, (2) infiltration into the vegetation cover, soil, and/or snow prevents further movement, or (3) increased viscosity due to low temperatures slows movement. Tundra relief on the coastal plain of the North Slope is low enough to limit the spread of spills. During summer, flat coastal tundra develops a dead-storage capacity averaging 0.5 to 2.3 inches deep (Miller et al. 1980), which can retain 12,600 to 63,000 gallons of oil per acre. Even at high water levels, the tundra vegetation tends to act as a boom, with both vegetation and peat functioning as sorbents that allow water to filter through, trapping the more viscous oil (for example, see Barsdate et al. 1980). On the other hand, even small spills can spread over large areas if the spill event includes aerial, pressured discharge. With the high-velocity, bi-directional winds on the North Slope, oil can be misted substantial distances downwind of a leak (BLM and MMS 2003). For example, in December 1993 an ARCO drill site line failed, and 40 to 160 gallons of crude oil misted over an estimated 100 to 145 acres (Ott 1997).

The rate of oil movement and depth of penetration into tundra depends on a variety of factors. If released onto dry tundra, oil can penetrate the soil because of the effects of gravity and capillary action until it encounters an impervious layer of water, ice, or tight soils. The rate of penetration depends on the season, temperature, soil saturation, nature of the soil, and the type of oil. In summer, spills may penetrate the active layer and then spread laterally on the frozen subsurface, accumulating in local depressions. From there, the oil may penetrate into the permafrost layer through cracks in the permafrost (Collins et al. 1993). Precipitation can increase dispersion over thawed soils (Chuvilin et al. 2001). Also in summer, there may be large areas of the tundra where there is a layer of standing water though not a pond or lake *per se*. In these areas, the oil would likely float on the water until it reaches dry ground or tundra vegetation including tussocks that are above the water and may become oiled. This vegetation may act as a barrier to further spreading of the oil.

Oil and some chemicals may effectively contact herbicides, which could result in barren patches of tundra potentially subject to thermokarsting.

In winter, the snow cover or frozen soil can slow the spreading of oil, depending upon the temperature of the oil, topographic relief, and the amount of snow cover. Snow cover may act as an absorbent, slowing the spread of oil and reducing the amount of the spill that reaches the tundra surface. During winter, oil may spread on the surface of the frozen soil, and penetration of oil into the soil is generally limited. However, pore space in the soils that is not filled with ice may allow spilled oil to move into the frozen soil (Yershov et al. 1997, Chuvilin et al. 2001).

Salt water spills on tundra generally behave similar to oil spills. The primary difference is that salt water may freeze at temperatures just below freezing, depending upon the discharge temperature and overall salinity of the salt water. Freezing can prevent the salt water from spreading very far, especially in winter. However, in the summer, salt water is much less likely to freeze and it may flow farther through the vegetation than would the same volume of oil. The salt water also is more likely to penetrate farther into the soil and the permafrost to the extent that there are voids in the permafrost. Finally, the salts in salt water do not weather as oil does and these salts would likely persist until they are diluted and/or transported from the area by freshwater flows from precipitation, floods, or flushing activities of the cleanup and restoration crews.

FATE AND BEHAVIOR OF SPILLS INTO MARINE OR FRESH WATER

Weathering processes generally would be similar in fresh water and coastal marine regimes in the Plan Area. Seasonal ice cover could greatly slow weathering in both regimes.

Oil spreading on the water surface (but not necessarily the transport of oil by moving water) would be restricted in most Plan Area waters. Because of the increased viscosity of oil in cold water, oil spills in Plan Area lakes, rivers, and marine waters would spread less than in temperate fresh or marine waters. The exception to this would be a spill in shallow, marshy, or ponded tundra or flooded lake margins in summer, which could spread similarly to a temperate spill. The exception is possible because these shallower waters are often warmer than other tundra waters (Miller et al. 1980) and warm enough to lower oil-slick viscosity.

An oil spill in broken ice in the Nigliq Channel or Harrison Bay would spread less than on an open lake and would spread between ice floes into any gaps greater than approximately 4 to 6 inches (Free et al. 1982). An oil spill under ice in lakes, rivers, or Harrison Bay would follow the general course described below:

- The oil would rise to the under-ice surface and spread laterally, accumulating in the under-ice cavities (Glaeser and Vance 1971, NORCOR 1975, Martin 1979, Comfort et al. 1983).
- For spills that occur when the ice sheet is still growing, the pooled oil would be encapsulated in the growing ice sheet (NORCOR 1975, Keevil and Ramseier 1975, Buist and Dickens 1983, Comfort et al. 1983).
- In the spring, as the ice begins to deteriorate, the encapsulated oil would rise to the surface through brine channels, stress cracks, and pressure ridges in the sea ice or water channels in lake ice (NORCOR 1975, Purves 1978, Martin 1979, Kisil 1981, Dickins and Buist 1981, Comfort et al. 1983) or by ablation of the surface layers of ice. If the ice breaks-up before the oil is exposed, then the oil would be transported downcurrent or downwind in the broken ice and could be widely distributed along the creek and riverbanks, in the Colville River Delta, and possibly even as far as Harrison Bay.

The presence of currents could affect the spread of oil under the ice if the magnitude of those currents is large enough. A field study near Cape Parry in the Northwest Territories reported currents up to 0.2 knots. This current was insufficient to move oil from under the ice sheet after the oil had ceased to spread (NORCOR 1975). Laboratory tests have shown that currents in excess of 0.3 to 0.5 knots are required to move oil collected in under-ice depressions (Cammaert 1980). Current speeds in the nearshore Beaufort Sea, including Harrison Bay, generally are less than 0.2 knots during the winter (Weingartner and Okkonen 2001). The area of contamination for oil under ice could increase if the ice were to move. For example, because the nearshore Beaufort Sea, including Harrison Bay, is in the landfast ice area, the spread of oil from ice movement would not be anticipated until spring break-up; however, once break-up occurs the oil could be moved long distances rapidly.

The weathering processes that act on oil in and along a river or stream are similar in most cases to those for marine spills. The dynamics of a river or stream environment, however, have additional effects on the fate and behavior of spilled oil. Oil entering a river begins to spread in the same manner as in the marine environment, but the spreading motion would be overcome rapidly by the surface current at which point an elongated slick would form. The oil would flow downstream at the speed of the surface current. As the surface current speed increases with channel constriction and decreases with channel widening, the oil movement rate also would increase and decrease as the slick alternately passes through constricted meander bends and wider, straight channel sections. The effect of wind would slow or accelerate the downstream movement if the wind direction parallels that of the channel. With the sinuous character of most North Slope rivers, this could lead to alternate slowing and acceleration as the oil slick moves downstream. A second effect of wind would be to move the oil toward the downwind riverbank, contributing to the stranding of oil. Water near the center of a stream channel generally would flow faster than water near the banks or bottom of the channel where the retarding forces of friction with the channel are greater. This difference in current speed and the resulting shearing forces between water layers is typically the major mixing mechanism that causes a slick to spread as it moves downstream. The resulting spread of the oil along the axis of flow controls the plume shape and size, and the distance over which the oil concentration would remain above a particular level of concern. The leading edge of the slick could move as a relatively sharp front (at the current speed in the middle of the channel); however, mixing would continuously exchange water and oil between the slower, near-bank regions and the faster-flowing, center regions of the river. From a practical point of view, this means that, although it would be possible to predict the initial arrival of oil at a point along the river, it would be considerably more difficult to estimate when the threat is past, because the areas of slower currents could continue to supply oil to the main stream channel, even after the leading edge is past (BLM and MMS 2003).

Stream flow is unidirectional in a long, straight channel; however, few natural channels in this region are straight and uniform for more than a few hundred yards. As water flows around a bend in a river or encounters an eddy, centrifugal force tends to pile water up along the outside edge of the turn. This secondary flow slightly deflects the streamlines in the flow as the river moves around bends. More importantly, secondary flow helps move oil particles across the shear boundaries and greatly increases the spreading, or dispersion, of the slick in the downstream direction. Thus, oils tend to spread more rapidly, decreasing their peak concentrations relative to what would be expected for a straight channel (BLM and MMS 2003). Shear-dominated flows cause another effect that characterizes river spills. Shear in currents along the banks and river bottom are typically the major source of turbulence in rivers, in contrast to surface-wave activity in oceans. Mixing and dispersion caused by the interaction of the shear and the turbulence can move substantial amounts of oil below the surface (particularly if it is relatively dense, such as a heavy fuel or crude oil, or if it is finely distributed as droplets). The shear-dominated river regimes tend to produce spill distributions having higher subsurface oil concentrations than would be expected in marine spills (BLM and MMS 2003). This turbulence increases with increased velocity of flow and bed roughness. In faster flowing conditions, the geographic spread and the affected area could be greater than under slower flow conditions, although local concentrations of oil could be greater for slower streams.

The rate of movement of the leading edge of oil spilled into a river could be virtually the same as the maximum surface current in the river. Near-surface current velocities in the range of one to two knots have been measured in the Ublutuoch River, which could result in oil moving downriver approximately 30 to 60 miles per day (PAI 2002a, PAI 2002d, CPAI 2003p). These values provide an estimate for the speed at which the leading edge of a surface oil slick could travel downstream.

For any oil that enters a river, irrespective of flow velocities or water levels, some of the oil would end up on the riverbanks or in flood flows, even on the tundra, and in normally isolated tundra ponds. The most common riverbank substrate material in the Plan Area is sand, and the most common bank forms are sand point bars or channel margin bars and sand- or peat-eroding cut banks. It is not practical to predict or estimate how much oil per unit area would be stranded on a riverbank or reach as this depends on the following factors:

- Physical character of the oil, which would change as the spilled oil weathers
- Physical character of the riverbank material, such as sand, grass, peat, etc., which would vary considerably even over short distances
- Speed at which the water would flow at the water-sediment interface
- Size of any wind-generated waves on the river surface that would spread the oil over a band above the water level
- Changes in the water level and flow volume through the time that oil would pass through a reach; these changes would depend upon both season and recent/ongoing storm events
- Direction, persistence, and magnitude of winds occurring during and after the oil spill event; strong persistent winds could strand oil against lee banks and/or create surface currents that could be stronger than the instream, near-surface velocities would otherwise be

As a general guide, if one assumes that stranded oil would be uniformly 0.4 inch thick and evenly covered a band 6 inches wide, then 42 gallons of stranded oil would cover 35,000 feet or 6.5 miles of riverbank or 3.25 river miles if the riverbanks on both sides were coated equally. For example, in this scenario, 42 gallons of stranded oil from a spill at the Ublutuoch River crossing would oil both banks more than half way to the mouth of the river where it flows into Fish Creek.

The point bars and channel margin bars are dynamic features, and the sand is constantly redistributed by water action so that stranded oil could be eroded, typically, on upstream sections of a bar, or buried on the downstream sections of a bar. Cut banks are erosion features so that oil stranded on an active face would not persist and could be remobilized in a matter of minutes or hours if active bank erosion were occurring. If the water level drops and oil is stranded above the water line, erosion at the base of the bank could cause slumping and re-entrainment of the oil in the river. Oil could typically persist in the following areas:

- Stable vegetated banks where the oil could coat branches, leaves, and grass
- Ponds or channels where the oil is left above the level of the river by falling water levels
- Areas of quiet water or eddies at the inside of river bends on a meandering channel
- Other pools or backwaters where velocities are slower.

4.3.3 SUMMARY OF IMPACTS TO RESOURCES FROM VERY SMALL TO LARGE SPILLS

4.3.3.1 Overview

This section focuses on the potential impacts to each of the resource categories resulting from very small spills (less than 10 gallons and mostly less than one gallon) to large spills (1,000 to 100,000 gallons) (Section 4.3.2.3). Very large spills (greater than 100,000 gallons) are considered in more detail in Section 4.3.4.

The impact assessment is based on the past 30 years of North Slope experience. The vast majority of spills have been very small or small, contained within the boundaries of the secondary containment or at least on the gravel pads and roadways, cleaned up expeditiously, and resulted in impacts to the natural resources of the North Slope that are limited in area, duration, and size. However, large spills have occurred or could occur, albeit with low probability, and the impacts of those are included here.

This section summarizes impacts by resource category for Alternative A – CPAI Development Plan and draws heavily upon and incorporates by reference the impact assessments from the Northwest National Petroleum Reserve-Alaska Draft IAP/EIS (BLM and MMS 2003), as well as information in other recent North Slope EISs (BLM and MMS 2002, BLM and MMS 1998b, TAPS Owners 2001a). Substantial differences in Alternatives B, C-1, C-2, D-1, D-2, and F are then described. To reduce redundancy, there is no repeat of each of the resource-specific impact assessments where they are essentially the same in Alternatives B, C-1, C-2, D-1, D-2, and F as those in Alternative A. Alternative E is the no-action alternative and would not result in any spill-related impacts from the ASDP development.

This section also evaluates the potential impacts of FFD on each resource category in Alternative A. For many of the resources (for example, paleontological, soils, air, economy, visual, and recreational), the impacts would be essentially the same as those for the CPAI Development Plan and, to reduce redundancy, the appropriate descriptions are referenced. For others (for example, fish, spectacled eiders, marine mammals, subsistence use of caribou) where the location of production pads and/or processing facilities result in potential spills affecting resources that the CPAI Development Plan might not, an assessment of potential impacts of the FFD is provided.

4.3.3.2 Spill Scenarios

A range of spill scenarios is provided to facilitate the impact assessment.

VERY SMALL (LESS THAN 10 GALLONS) AND SMALL (10 - 99.5 GALLONS) SPILLS

The most common scenarios are the very small spills and small spills of material, usually diesel, hydraulic fluid, transmission oil, and antifreeze, on gravel pads, roads, and airstrips, or on ice roads and pads. Rarely do these spilled materials reach the tundra or water bodies. When they do, they usually impact the area adjacent to the road or pad and are limited in the area they affect. However, some of these small spills are from salt water, oil, or produced fluids lines, and they could occur on the tundra or into water bodies remote from the roads and pads.

MEDIUM (100 – 999.5 GALLONS) AND LARGE (1,000 TO 100,000 GALLON) SPILLS

A similar scenario exists for medium-to-large spills except they are much less common and they do occasionally reach the tundra or water bodies adjacent to the roads, pads, and airstrips. These spills are more likely to be of salt water, oil, or produced fluids, although medium to large spills of antifreeze, diesel, and drilling muds may occur.

PIPELINE SPILLS

Pipeline spills are likely to reach tundra and/or adjacent water bodies, especially if they are large and occur in the ice-free seasons. The medium to large pipeline spill scenarios could result in impacts to creeks or rivers, as well as to the tundra. The main features of these scenarios are provided in Table 4.3.3-1. These scenarios were selected as reasonable worst-case incidents in terms of the largest volume that might be spilled to the water body or tundra, and of the diversity and sensitivity of environmental resources that might be impacted. The first four scenarios in Table 4.3.3-1 are guillotine ruptures of the pipelines crossing a major creek or river. The actual volumes spilled could vary depending upon location and activation methods and times for valves or vertical loops, pressure in the line, actual location of the break, and other factors; however, the type and magnitude of potential impacts is likely to be similar over the potential range of spill volumes. The fifth scenario in Table 4.3.3-1 is from a pipeline to the tundra. The spill scenario is a proxy for substantial spill to the tundra of produced fluids, salt water, and, in the FFD, Sales Oil. The actual length of line that drains after rupture could vary substantially, usually being shorter than the estimated 7.8 miles between CD-7 and CD-6. Also, to the extent the pipelines follow the topographic contours and there are low spots in the pipelines (or vertical loops or valves), the amount of oil that spills could be much smaller. However, until the final alignments are determined and the pipelines constructed, the largest and most likely potential spill volumes cannot be estimated precisely or accurately.

TABLE 4.3.3-1 POTENTIAL PIPELINE SPILL VOLUMES

		Produced 3-Phase Fluids		Salt water[e]		Diesel		Sales Oil (FFD only)	
Pipeline Segments	**Length (ft)**	**Size (in)[g]**	**Vol (gal)[a]**	**Size (in)**	**Vol (gal)**	**Size (in)**	**Vol (gal)**	**Size (in)**	**Vol (gal)**
Nigliq Channel	2500[b]	24	11,750	14	19,992	–	–	14	23,100
Ublutuoch River	2500[f]	24	11,750	14	19,992	–	–		
CD-1-CD3	34,054	18	86,688	10	127,470[c]	2	5,558		
CD-22-CD6 (Fish Creek in FFD only)	55,864	24	141,666	14	446,732				
CD7-CD6 (Tundra crossing)[d]	41,184	24	193,571	14	329,340	–	–	14	329,340

Notes:

[a] Assumes that the produced fluids are approximately 20 percent liquid, consisting of oil and brine in some currently unspecified proportion that could be deposited on the surface.

[b] Length of segment that would drain

[c] Based on CPAI response to ENTRIX request for information (Shifflet 2003)

[d] Assumes no valves between pads and the entire segment could drain. Topographic relief as well as location of valves and/or vertical loops for the final pipeline route could result in substantially smaller spill volumes.

[e] Static volume assuming entire length of line drains and valves at the ends of the segment stops flow immediately.

[f] Based on the assumption that all major river/creek crossings would have valves or vertical loops approximately 2,500 feet apart on either side of the river.

[g] Pipeline size is inches in diameter.

PROXIMITY OF PADS AND PROCESSING FACILITIES TO MAJOR STREAMS AND RIVERS

The proximity of pads and processing facilities to major streams and rivers from which medium to very large spills of produced fluids, oil, and salt water, as well as diesel and other materials in bulk storage tanks and containers could occur may be an important factor in the impact scenarios. In general, if the spilled material flows to the tundra, the material would probably not disperse very far. However, if a medium- to-large (or very large) spill reaches a flowing creek or river, the material could be dispersed for substantial distances downstream. In flood flows, the material also could be distributed over the flooded tundra, and into tundra ponds and lakes. As shown in Table 2.3.11-2, most of the pads and hypothetical processing facilities are greater than 0.5 miles from the nearest major river or stream. Whether a spill would reach these rivers or streams would depend upon several variables including the type, temperature, and volume of material spilled, the topographic relief and slope, air temperature, presence of snow and/or vegetation, and response time and actions.

RESOURCE-SPECIFIC IMPACT ASSESSMENT

Soils

Spills that are not confined to ice or gravel pads and roads could affect the soils, especially where there is little to no vegetation or snow cover to provide a barrier and "sorbent" for the spilled material. Crude oil in the produced fluids and Sales Oil (FFD only), lubricating oil, and similar heavy oils would be less likely to reach the surface soil layers than would refined oil (for example, diesel), which could infiltrate through the vegetation. Salt water is likely to reach the soil especially in the warmer snow-free seasons because its low viscosity would allow it to penetrate the vegetation and even thin snow layers. The depth of penetration of oil into the soil would depend on the porosity of the soil and the extent to which it is frozen or saturated with liquid water. The area affected would be limited to that area immediately adjacent to and covered by the spill.

Spills could affect soils indirectly by affecting the vegetation, which in turn could die and expose the soil to thermokarsting, wind erosion, etc., even if the soil itself were not directly affected by the spilled material.

Spill cleanup is more likely to affect the soils than the presence of the spilled material itself unless the cleanup is well controlled and heavy traffic and digging are minimized (especially for summer spills). Spill cleanup mitigates impacts on soils only if cleanup methods and operations are very carefully controlled and minimize surface disturbance.

Spilled salt water would be likely to infiltrate to and into the surface soil layers, even if there is vegetation or snow cover. Depending on the porosity of the soil and the extent to which the pore spaces are filled with ice, the salt water could penetrate to or below the tundra vegetation root zone. In locations such as the outer regions of the Nigliq Channel and Colville River Delta, as well as the estuarine region of Fish Creek, where the vegetation includes halophytic (salt-tolerant) plants, the impacts of salt water spills could be of smaller magnitude and duration than in most of the rest of the tundra where the plants are non-halophytes. The soils affected by salt water spills could take as little as one year and possibly up to several years to return to normal, depending on the initial salinity of the salt water and the amount of flushing from precipitation and flooding (McKendrick 2000, 2001).

This impact assessment also applies to the FFD for the Plan Area. Salt water spills could have a lesser impact on the soils supporting halophytic plants in the estuarine reaches of the Kogru River and Kalikpik River because (1) the halophytic plants are salt tolerant, and (2) all but a large to very large salt water spill are likely to be substantially diluted with the Kalikpik River freshwater flow by the time the spilled salt water reaches the estuary located several miles downstream from the hypothetical pipeline crossing.

Paleontological Resources

Most spills are confined to a pad or roadway or to an area adjacent to them. The primary exceptions are spills from pipelines to tundra, remote from the roads and pads. In the construction stage, most spills would occur on an ice pad or ice road during winter conditions, where snow and ice would limit impacts to paleontological resources and cleanup is less invasive than in a summertime terrestrial spill. In any case, paleontological resources usually are so deeply buried that they probably would not be affected by either a spill or subsequent spill cleanup. The effects of spills and spill cleanup associated with drilling and production would be similar to those associated with construction activities except that they could occur during the snow-free months. Although cleanup from these spills might be more invasive because of the non-frozen surface environment, there is little chance that subsurface paleontological resources would be affected. If present, surface paleontological remains could be affected in the same manner as surface cultural material. However, because the occurrence of surface paleontological remains is rare and, where known, would be avoided by plan facilities, the probability of any impact is remote.

This impact assessment also applies to the FFD for the Plan Area.

Water Resources

In the unlikely event that spilled material flows to or is deposited on the water bodies near the pads and/or leaks from a pipeline, it could affect the water resource value of that water body. The primary resource use of water bodies, other than as habitat for wildlife and fish, is to support the oilfield activities. A key use is water from the Permitted Lakes (see Figure 2.4.1.1-11). In the CPAI Development Plan, there is a potential for a medium to large spill from pipelines or from a vehicle or equipment on roads to reach these lakes between CD-7 and CD-6 in Alternatives A, B, C and F. In Alternative D (the roadless alternative) and for CD-3 in Alternatives A, B, and F (which is also roadless), the likely potential source would be only from pipelines.

If the spilled material is oil, cleanup actions could adversely affect water resources until the petroleum residue weathers or could be flushed from streams. This process could take a few weeks in a fast-flowing stream to a decade or longer in lakes and ponds.

Spills of most of the chemicals used in the oil fields and salt water generally would be rapidly diluted and have little impact in a large lake or river. In small lakes, tundra ponds, and shallow water tracks, the impacts could be greater, with waters potentially remaining toxic to sensitive species for up to a few years. These spills could be pumped out of the water body, if confined, or neutralized, and then diluted with uncontaminated fresh water.

This impact assessment also applies to the FFD for the Plan Area. In the FFD, additional Permitted Lakes near HP-16 and HPF-1, near the road between HP-2 and HP-10, and near the pipeline and road between CD-5 and Nuiqsut could also be affected.

Surface Water Quality (Fresh Water)

Spills could affect freshwater quality if the spilled material reaches water bodies either directly or from flowing over the tundra. However, the vast majority of all spills are confined to a pad, road, or airstrip, to an adjacent area, or to the area under a pipeline. Most spills are very small to medium in volume (i.e., fewer than 1,000 gallons). In addition, for two-thirds of the year, spill response could remove almost all of an oil, chemical, or drilling mud spill from frozen tundra or ice-covered water bodies prior to snowmelt. During one-third of the year (late May through late September), spills could reach and affect wet tundra and tundra ponds and lakes, as well as creeks and rivers before spill response is initiated or completed.

If the spilled material, especially petroleum hydrocarbons and other organics, would reach the freshwater bodies, there could be an impact to water quality in reduced dissolved oxygen concentrations and increased toxicity to aquatic organisms.

Dissolved-oxygen concentrations in tundra waters could be affected by spilled oil in summer. The National Petroleum Reserve-Alaska experiment provides an illustration of the potential impacts (Miller et al. 1978, Barsdate et al. 1980, Hobbie 1980). In summary, 210 gallons of Prudhoe Bay crude were spilled into a 0.07-acre tundra pond. Dissolved-oxygen concentrations a week after the spill were reduced by approximately 4 milligrams per liter (mg/l) below levels in a control pond, and some measurements within inches of the surface, just under the slick, were less than 5 mg/l (state standard for protection of wildlife). At the 4-inch water depth (average pond depth, [Miller et al. 1980]), outside the slick, oxygen concentration was within the expected normal range of 10.8 mg/l versus 11.4 mg/l in the control pond. The oxygen deficit under the slick (and also in the shallower waters of the control pond) was attributable to decreased oxygen influx from the air because of the relative impermeability of the oil slick to oxygen and to the relatively high rate of natural sediment respiration in coastal tundra ponds. The oxygen deficit was not attributable to oil-enhanced respiration of oil-biodegrading microorganisms in the pond.

In winter, even under ice, an oxygen deficit would not be expected to result from a small spill in most waters because low biological abundance and activity means that sediment and water column respiration rates are low to negligible. In addition, sediment respiration has even less relative effect in the thicker water column of lakes deep enough not to freeze solid in winter. Such lakes, even those that hold fish, tend to be supersaturated with dissolved oxygen in winter, to levels above the state water-quality standard of 110 percent saturation (BLM and MMS 1998). An exception might be if a spill were to occur underneath thick ice cover in very restricted waters holding a concentrated population of overwintering fish that already have depleted oxygen levels. These low oxygen concentrations could occur in the deeper pools of the Colville River, Nigliq Channel, and several of the other rivers and creeks in the Plan Area.

During open water periods in the Colville River Delta, Nigliq Channel, Ublutuoch River, and, for the FFD, in Fish-Judy Creeks, and Kogru River, there would be no detectable impacts on dissolved oxygen levels due to the spilled materials. The relatively high river volume (relative to the volume of oil) and the high rate of water flow would dilute the oil before there were any effects on dissolved oxygen concentrations.

The primary effect of a very small to large oil spill would be from direct toxicity to aquatic plants and animals. Long-term toxicity (up to a decade) can result from a small spill, as shown in the National Petroleum Reserve-Alaska experimental pond spill (Miller et al. 1978, Barsdate et al. 1980, Hobbie 1982). In a real oil spill, containment and cleanup response likely would recover the bulk of spilled oil, but sufficient oil could remain trapped in the sediments and/or aquatic vegetation to promote long-term, low-level toxicity on a local basis. Long-term toxicity would be less likely to occur in larger lakes and creeks or rivers because the oil would be diluted and/or dispersed with the sediment over large areas by currents and wind/wave action. Spills into the larger rivers and creeks (e.g., Colville River Delta, Nigliq Channel, Ublutuoch River, and, for the FFD, in Fish-Judy Creeks and Kogru River), especially during open water periods, might have toxicity impacts limited to the first few reservoir pools downcurrent of where the spill entered the river because of the large and rapid dilution of the oil relative to the flow volumes. In the smaller flowing creeks, the lower relative volume and rate of water flow could have direct toxicity impacts in the water column and sediments. Some toxicity might persist in these creeks for a few weeks to years, until toxic compounds were washed out of the oil trapped in the sediment or the oiled sediment was buried under cleaner sediment.

An oil spill reaching the larger tundra lakes (e.g., Nanuk Lake; see Figure 2.4.1.1-11) would result in a minimal effect on water quality. Dissolved oxygen levels would not be affected. Direct toxicity would be minimal because of the much greater dilution volume in these lakes than in the small ponds and lakes. The spreading of the spill over the lake surface could be considered an effect on water quality. This effect would exist for a few weeks, until either the slick was cleaned up or the oil stranded on the shoreline.

There are likely to be fewer spills that would affect freshwater bodies in Alternative D than in Alternatives A through C and F because much less vehicle and heavy equipment traffic would occur in the ice-free season when the freshwater bodies are most vulnerable. There would be more winter traffic and thus a greater chance of bulk container spills in Alternative D, but the spills are likely to be cleaned up quickly.

A salt water spill to smaller freshwater bodies could exceed state freshwater quality standards (State of Alaska, ADEC 1997), which prohibit total dissolved solids or salinity from exceeding 1.5 percent salinity. The treated seawater from Kuparuk Seawater Treatment Plant is approximately 3.3 percent much of the year and the brine in the produced fluids is likely to be approximately 2 percent (CPAI 2003q). In a year with high rainfall, some of the salt would be diluted and flushed from the tundra ponds and lakes during summer. Some of the seawater could settle into the deepest reaches of the contaminated waters. The freeze/thaw cycle in the Arctic and the depth of any lake reached by the spill would play a controlling role in the fate of the remaining contaminating salts from a spill (Hobbie 1984, Prentki et al. 1980, Miller et al. 1980, O'Brien et al. 1995).

This impact assessment also applies to the FFD for the Plan Area.

Marine Water Quality

Under any of the CPAI Development Plan alternatives, very small to medium spills (i.e., up to 1,000 gallons) of oil or other hazardous materials are unlikely to reach marine waters of Harrison Bay or the nearshore Beaufort

Sea in measurable amounts. Even if these spills reach the flowing waters of the creeks and rivers, the volume of the spilled material would be diluted before it is discharged to the marine waters where it would be further diluted rapidly to very low concentrations approaching ambient conditions. No facilities or pipelines are proposed on or immediately adjacent to the marine coastal zone and, with exception of HP-22, HP-5, HP-13, and HP-14 in the FFD, the sources of spilled material are generally far enough from marine waters that, by the time spilled material reaches the marine waters, the spilled material would have very little impact to marine water quality or resources.

If a medium to large spill enters a river resulting from an undetected slow leak, the oil could be transported over the landfast ice in the marine environment during break-up before the oil could be cleaned up. The transport of the oil along with ice and fresh water would occur during the break-up floods. The flood flow volumes would dilute the oil and disperse it over a large area of the landfast sea ice where it would be further diluted as it mixes with the marine water and flood waters. The dilution factor is likely to be great enough that the oil would be essentially undetectable in the marine waters.

Any spill of salt water that is eventually transported to the marine environment would have no impact on the marine water quality of organisms. The salt water is near to ambient salinity so that even if it could be discharged directly to the marine waters (no sources are proposed in the CPAI Development Plan or the FFD that are likely to result in this), the spilled salt water would rapidly be diluted to ambient salinity.

Estuarine Water Quality

Most spills are very small to small and would not leave the pads, roads, airstrips, or other facilities, so they would not affect estuarine water quality or resources. Spills (primarily medium to large) from pipelines directly into rivers and creeks flowing to the Nigliq Channel, Colville River Delta, and/or Harrison Bay or lower Kogru River, could affect estuarine water quality at the mouths of these rivers and could measurably degrade estuarine water quality and shorelines of the Plan Area. On some shoreline types (see Figures 3.2.1.1-2 and 3.2.1.1-3), spilled oil could persist for several years, and possibly for more than a decade. On other shorelines, especially high energy, eroding ones, the stranded oil would likely not persist for more than a few months to a couple of years.

If a medium to large oil spill were to occur during the open water or broken-ice seasons from the pipeline between CD-1 and CD-3, especially where the pipeline crosses the channels in the Colville River Delta, or from the CD-3 pad, the oil could reach the estuarine waters of the Colville River Delta and lower Harrison Bay. This oil could be dispersed over and dissolved in the water column and could be incorporated into the sediments (BLM and MMS 2002). The oil could measurably degrade estuarine water quality and contaminate shorelines, in spite of proposed spill responses. The Liberty EIS (MMS 2000b) concluded that hydrocarbons dispersed in the water column from a medium to large (greater than or equal to 21,000 gallon) oil spill could exceed the 1.5-ppm acute toxicity criterion during the first day in the immediate vicinity of the spill (BLM and MMS 2002). Further, the hydrocarbon concentration could exceed the 0.015-ppm chronic criterion for up to 30 days in an area that ranges up to 70 square miles, which would include the size of most of the estuarine habitats in the Plan Area.

This impact assessment also applies to the FFD for the Plan Area. In the FFD, additional estuarine habitats that might be affected include the mouths of Fish and Judy Creeks, Kalikpik and Kogru Rivers, and the northeastern Colville River Delta near HP-4, HP-7, HP-12, HP-13, and HP-14.

Air Quality

Based upon modeling work by Hanna and Drivas (1993), the majority of volatile organic compounds (VOCs) from crude oil spills likely would evaporate almost completely within a few hours after the spill occurred, especially during the late spring-early fall when most of the biological resources are present on the North Slope. Emissions of VOCs, such as benzene, ethylbenzene, xylene, and toluene, would peak within the first several hours after the spill starts and drop by two orders of magnitude after approximately 12 hours. The heavier compounds take longer to evaporate, particularly at the colder temperatures typical of the Plan Area, and might not peak until more than 24 hours after the spill. In the event of an oil spill on land in the National Petroleum

Reserve-Alaska, the air quality effects would be less severe than on water because some of the oil could be absorbed by vegetation or into the ground. However, some effects might last longer before the VOC compounds completely dissipated.

Diesel fuel oil could be spilled during refueling, from a broken diesel pipeline, or from accidents involving vehicles or equipment. A diesel spill would evaporate faster than a crude oil spill. Ambient hydrocarbon concentrations would be higher than with a crude oil spill, but would also persist for a shorter time. Also, since any such spill would probably be smaller than potential crude oil spills, any air quality effects from a diesel spill likely would be even lower than for other spills.

There would be no air quality impacts associated with salt water spills.

The air quality impacts of oil spills would be localized and short term. The associated VOC air emissions would have little impact on the biological or physical resources of the Plan Area in either the CPAI Development Plan or the FFD.

Vegetation

Most spills will occur on ice or gravel pads, roads, and airstrips, and the spilled material will not leave the facility. Consequently, their effects would not reach and would have no impact on the vegetation. However, some of the medium to large spills could reach the adjacent tundra vegetation by (1) directly flowing from the facility, (2) depositing from aerial dispersal of fluids from a pressurized pipeline leak, or (3) spilling from a pipeline over the tundra.

Furthermore, approximately two thirds of the year, there is sufficient snow cover to slow the flow of spilled material and to allow spill cleanup efforts to occur before spilled materials spread substantial distances from the spill source. Thus, there would be a limited impact to vegetation from these spilled materials. However, there might be an impact from the cleanup operations if they are not implemented carefully and with regard for minimal disturbance of the surface soils and vegetation. During the other third of the year, there is less snow cover and the spilled materials may flow further on the tundra depending upon topographic relief, temperature, material spilled, and vegetation type, density and height.

Most oil spills would cover less than an acre but potentially up to several acres if the spill were a windblown mist. Overall, past spills on Alaska's North Slope have caused minor ecological damage, and ecosystems have shown a good potential for recovery with wetter areas recovering more quickly (Jorgenson and Martin 1997, McKendrick 2000b). Oil spills on wet tundra kill the moss layers and aboveground parts of vascular plants and sometimes kill all macroflora at the site (McKendrick and Mitchell 1978). Damage to oil-sensitive mosses could persist for several years, if the site is not rehabilitated (McKendrick and Mitchell 1978). The length of time a spill persists depends upon soil moisture and the concentration of the product spilled. McKendrick (2000b) reported that complete vegetation recovery occurred within 20 years on a wet sedge meadow without any cleanup. A dry habitat exposed to the same application supported less than 5 percent vegetative cover after 24 years. For the most part, tundra oil spills would be very local (less than one acre) in their effects and would not be expected to contaminate or alter the quality of habitat outside this limited area. However, some local contamination of tundra vegetation is expected to occur near production wells and processing facilities. Spills that occur within or near streams and lakes could affect foraging habitat along these water bodies.

A spill of salt water has the potential to affect vegetation. The size of the area affected would depend on the terrain and land cover at the spill site and would be proportional to the amount of salt water spilled. If such a spill were to occur within a community of halophytic plant species, there could be little effect. Otherwise, depending on the specific situation under which the spill occurred, the result could vary from little impact to total plant death in the area affected, with eventual replacement of the vegetation community by halophytic species. According to McKendrick (1999b, 2000b), brine (and other salt water) spills kill plants on contact and increase soil salinity to the point that many species cannot survive. Unlike oil, salts are not biodegradable, and natural recovery occurs only after salts have leached from the soil. A spill would have adverse effects on salt-intolerant vegetation near the salt water pipeline, but the amount of tundra habitat affected would be small, no more than a few acres. Thus, potential salt water spills are not likely to affect forage availability for terrestrial mammals in the Plan Area.

The potential impacts to vegetation could be less in Alternative D (roadless) than for Alternatives A through C and F because there would be less risk of oil spills in Alternative D from vehicle and heavy equipment accidents during the ice/snow-free season. The increase in vehicle and equipment, as well as bulk fuel transport in winter in Alternative D, could result in more spills on ice roads and pads, but the spilled material would be contained by and cleaned up from the snow and ice before it could contact the vegetation.

This impact assessment also applies to the FFD for the Plan Area.

Freshwater and Anadromous/Amphidromous Fish

Spills could affect freshwater and anadromous/amphidromous fish while they are in fresh water (hereafter called freshwater fish in this section), if the spilled material reaches fish habitats either directly or from flowing over the tundra. However, the vast majority of all spills are confined to a pad, road, or airstrip, to an adjacent area, or to the tundra area under a pipeline. Most spills are very small to medium in volume (i.e., less than 1,000 gallons). Finally, spill response would remove almost all of an oil, chemical, or drilling mud spill from frozen tundra or ice-covered water bodies prior to snowmelt for two-thirds of the year. During one-third of the year (late May through late September), spills could reach and affect tundra ponds and lakes, as well as creeks and rivers, before spill response is initiated or completed.

The effects of oil spills on freshwater fish have been discussed in previous Beaufort Sea EISs (e.g., BLM and MMS 2002, USACE 1999), which are incorporated here by reference and summarized. Oil spills have been observed to have a range of effects on North Slope fish. (For more detailed discussions, see Starr et al. 1981, Hamilton et al. 1979, and Malins 1977.) The specific effect depends on the concentration of petroleum present, the length of exposure, and the stage of fish development involved (larvae and juveniles are generally most sensitive). If lethal concentrations are encountered (or sub-lethal concentrations over a long enough period), fish mortality might occur. However, mortality caused by a petroleum-related spill is seldom observed except in small, enclosed water bodies and in the laboratory environment. Most acute-toxicity values (96-hour lethal concentration for 50 percent of test organisms [LC50]) for fish are generally from 1 to 10 ppm of the toxic hydrocarbons. Concentrations observed under the oil slick of oil spills have been less than the acute values for fish and plankton. For example, extensive sampling following the Exxon Valdez oil spill (approximately 11,000,000 gallons in size) revealed that hydrocarbon levels were well below those known to be toxic or to cause sub-lethal effects in fish and plankton (Neff 1991). The low concentration of hydrocarbons in the water column following even a large oil spill appears to be the primary reason for the lack of lethal effects on fish and plankton. The concentration in flowing rivers and creeks of the Plan Area also would be relatively low, even for medium to large oil spills.

However, if an oil spill of sufficient size were to occur in a small body of water with restricted water exchange (e.g., tundra ponds, small slow-flowing creeks) and containing fish, lethal and sub-lethal effects could occur for the fish and food resources in that water body. Toxic concentrations of oil in a confined area would have greater lethal impacts on larval fish versus adults. McKim (1977) reviewed results from 56 toxicity tests and found that, in most instances, larval and juvenile stages were more sensitive than adults or eggs. Increased mortality of larval fish is expected because they are relatively immobile and are often found at the water's surface where contact with oil is most likely. Adult fish would be able to avoid contact with oiled waters during a spill in the open water season but survival would be expected to decrease if oil were to reach an isolated pool of ice-covered water.

An example of the impacts to fish food resources is provided by Barsdate et al. (1980), who studied the limnology of an arctic pond near Barrow with no outlet, after an experimental oil spill. They found that half of the oil was lost during the first year. The remaining oil was trapped along the edge of the pond; most of it sank to the bottom by the end of summer. Researchers found no change in pH, alkalinity, or nutrient concentrations. Photosynthesis was briefly reduced and then returned to normal levels after several months. *Carex aquatilis*, a vascular plant, was affected after the first year because of emerging leaves encountering oil. Certain aquatic insects and invertebrates that lived in these plant beds were reduced in numbers, presumably from entrapment in the oil on plant stems. Some of the insects were still absent six years after the spill. There were no fish in this pond; therefore, the impact of the loss of a prey base to the fish could not be measured. Reducing food resources in a closed lake or pond, as described above, would decrease fitness and potentially reduce reproduction until prey species recovered.

Another potential impact could occur if oil that spilled before or during the spring floods (such as may occur from a structural failure) was dispersed into some of the tundra lakes that have continuous or ephemeral connection to the rivers and large creeks (Section 3.3.2.2 for discussion of perched, tapped, and drainage lakes). Lethal effects to fish in streams and some lakes are unlikely during high water events such as breakup because toxic concentrations of oil are unlikely to be reached. However, toxic levels may be reached in lakes that are normally not connected to the river/creek system except during the spring and maybe fall high-water periods. Fish are transported to these lakes and become “landlocked” until the next high-water event. If the oil concentrations in the water column reach toxic levels, these fish could suffer mortalities or injury.

Although lethal effects of oil on fish have been established in laboratory studies (Rice et al. 1979, Moles et al. 1979), large kills following oil spills are not well documented. This is likely because toxic concentrations are seldom reached. In instances where oil does reach the water, sub-lethal effects are more likely to occur, including changes in growth, feeding, fecundity, survival rates, and temporary displacement. Other possibilities include interference with movements to feeding, overwintering, or spawning areas, localized reduction in food resources, and consumption of contaminated prey.

Most oil spills are not expected to have a measurable effect on arctic fish populations in the Plan Area over the life of the CPAI Development Plan or the FFD. Oil spills occurring in a small body of water containing fish with restricted water exchange might be expected to kill a small number of individual fish, but are expected to have no measurable effect on arctic fish populations.

A potential spill from an HDD line under the Nigliq Channel in Alternative D may impact water quality and fish directly and other water-associated resources (e.g., birds, riparian habitats) as well as subsistence and recreational uses of the downcurrent areas. The spill may take some time to work its way from the pipeline to the sediment surface and, in a sudden or large to very large spill, the spill may be detected before it reaches the Nigliq Channel water body. However, if the spill goes undetected either remotely or during surveillance inspections, it will be underwater and may go on for days to weeks. Especially under ice, it will likely not be detected for months and the volume of oil could be substantial compared to the volume of the receiving water downcurrent from the spill. Fish in the deeper pools may be exposed and would likely die. Early-arriving birds may be exposed in any open water pools and cracks in the river ice. A catastrophic failure of the HDD pipeline would be more easily and rapidly detected. However, depending upon the season of occurrence (e.g., winter freeze-up compared to spring break-up or to summer open water), containment and cleanup of a large or very large oil spill could be difficult. The energized fluid released would mix with water and the oil is likely to emulsify, dissolve, disperse, and adhere to sediment particles. Fish as well as birds, other aquatic animals and plants, and riparian habitats could all be impacted for a substantial portion of the downcurrent channel.

The effects of salt water spills on freshwater fish populations would depend on the specific location, size, and timing of the spill. No effect would be expected during the winter period when the surface is already covered by ice. During the spring and summer, impacts from large quantities of salt water entering a fish-bearing freshwater environment would range from no effect on freshwater fish to lethal effects, depending on the specific water body involved, the size and salt concentration of the salt water spill into that water body, and the rate of freshwater exchange within that water body. Migratory fish are less likely to be affected by salt water spills because of higher tolerance to salt water and the probability that most would have already left the freshwater environment by spring in their migration to sea. In large freshwater bodies, salt water spills are expected to have from no effect to sub-lethal effects on freshwater fish because the salt water would be rapidly diluted to ambient salinity. In small water bodies with restricted water exchange, lethal effects could result from a medium to large salt water spill. Because of the small size of most of the salt water spills anticipated, and the low diversity and abundance of freshwater fish in most of the Plan Area, salt water spills are not expected to have a measurable effect on arctic fish populations in the Plan Area over the production life of the field.

This impact assessment also applies to the FFD for the Plan Area.

Marine Fish

In the CPAI Development Plan, even the large spills are unlikely to reach the marine waters of Harrison Bay at concentrations that would affect marine fish or their prey (Section 4.3.3). In all alternatives, a large spill from CD-3, or the pipelines between it and CD-1, could affect the estuarine fish in the Colville River Delta but probably would be diluted by the time the spill reached the much larger volume of marine water in Harrison Bay.

In the FFD, a large spill from HP-14, HP-13, or HP-12 could have the same limited impact to marine fish as a spill from CD-3, while a large spill from HP-22 could have a limited impact to the marine fish in the adjacent nearshore Beaufort Sea. The impacts are likely to be low-level chronic toxicity effects that would disappear in a few hours to days with additional dilution and weathering of the toxic materials.

Birds

Most spills are very small to medium volume and are contained on the ice or gravel pads, roads, and airstrips. If the spill does leave the gravel or ice structures, it is usually confined to small areas of the tundra vegetation and small ponds adjacent to the structure. Most pipeline spills are also contained on the tundra or tundra ponds, especially during the two thirds of the year when there is snow and ice over the tundra and water bodies. Some small to medium spills from pipelines or from vehicle accidents on bridges and culverts could result in spilled material entering flowing water bodies.

Spills on or near the roads, pads, or airstrips would have no impact to populations of birds, although a few individual shorebirds, waterfowl, raptors and very few passerine birds could be exposed to the spilled material, especially oil. These individuals are likely to die from hypothermia or from toxic effects of ingesting the spilled material. There could be some impact to a few individual birds, especially waterfowl and shorebirds using the small tundra ponds and creeks affected by the small to medium spills. Again, there would not be a population-level impact.

A large spill onto “dry” tundra could cause the mortality of small numbers of shorebirds and passerines from direct contact, especially with oil. If the spilled material were to enter local or inter-connected wetlands, small numbers of loons and waterfowl, plus additional shorebirds, could be exposed. Numbers of individuals oiled would depend primarily upon wind conditions, and numbers and location of birds following entry of the spill into the water. Impacts would not be detectable at the population level.

If the spill were to enter a creek or river, ranging from the many small creeks in the Plan Area to the Nigliq Channel and Colville River Delta, a variety of waterfowl and shorebird species could be present, particularly where the river empties into the estuarine environment. Such losses are likely to cause negligible impacts at the regional population level.

If gyrfalcons, peregrine falcons, rough-legged hawks, or owls were breeding in the spill vicinity, they could become secondarily oiled by preying on oiled birds. Mortality of breeding falcons likely would represent a minor loss for the local population, but (as with rough-legged hawks) is not likely to affect the regional population.

If a large spill were to move into the Colville River Delta, mouth of the Nigliq Channel, or the estuarine habitats of the other major rivers in the Plan Area, several waterfowl species that breed, stage, or stop there during migration would be at risk. A spill entering a river in spring could contaminate overflow areas or open water where spring migrants of several waterfowl species concentrate before occupying nesting areas.

It is unlikely that even a large spill would reach the marine environment with a substantial concentration of floating oil. If it did, it could contact loons and flocks of brant, long-tailed duck, and eiders staging before or stopping during migration in protected coastal habitats as well as black guillemots. Physiological effects on individual birds would be the same as described in the Northeast National Petroleum Reserve-Alaska IAP/EIS (BLM and MMS 1998). Lethal effects are expected to result from moderate to heavy oiling of any birds contacted. Light to moderate exposure could reduce future reproductive success because of pathological effects that interfere with the reproductive process caused by oil ingested by adults during preening or feeding.

Physiological effects of oil on individual birds would be the same as described in the Northeast National Petroleum Reserve-Alaska IAP/EIS (BLM and MMS 1998). Lethal effects are expected to result from moderate to heavy oiling of any birds contacted. Oiled individuals could lose the water repellency and insulative capacity of their feathers and subsequently die from hypothermia. Light to moderate exposure could reduce future reproductive success as a result of pathological effects on liver or endocrine systems (Holmes 1985) that interfere with the reproductive process and are caused by oil ingested by adults during preening or feeding. Stress from ingested oil can be an additive to ordinary environmental stresses such as low temperatures and metabolic costs of migration. Oiled females could transfer oil to their eggs, which at this stage could cause mortality, reduced hatching success, or possibly deformities in young. Flocks of staging eiders could contact oil in nearshore areas. Oil could adversely affect food resources, causing indirect, sub-lethal effects that decrease survival, future reproduction, and growth of the affected individuals. Because the spectacled eider population is small and declining, even relatively low mortality could represent a detectable impact.

Some brood-rearing, molting, or staging loons, brant, long-tailed ducks, or other waterfowl could contact oil in coastal and estuarine habitats. Mortality of molting long-tailed ducks from a spill entering protected areas could be substantial, but the population effect would be difficult to determine because numbers of that species are stable, declining, or increasing in various areas (Conant et al. 1997, Larned et al. 2001). Flocks of staging eiders could contact oil in nearshore or offshore areas. In addition, several thousand shorebirds could encounter oil in shoreline habitats (e.g., river deltas), and the rapid turnover of migrants during the migration period suggests many more could be exposed. A spill that enters open water off river deltas in spring could contact migrant loons and eiders.

A pipeline spill of salt water used in the waterflood enhancement stage of production would kill salt-intolerant tundra vegetation near the pipeline. The amount of tundra habitat affected is expected to be no more than a few acres. Such a small area of degraded habitat is not likely to result in loss of productivity by displaced breeders, and the loss will not be detectable at the population level.

In addition to the expected mortality due to direct oiling of adult and fledged birds, there could also be: mortality of eggs due to secondary exposure by oiled brooding adults; loss of ducklings, goslings and other non-fledged birds due to direct exposure; and lethal or sub-lethal effects due to direct ingestion of oil or ingestion of contaminated foods (e.g., insect larvae, mollusks, other invertebrates or fish).

The impacts of FFD would be similar except that several additional pads (HP-4, HP-5, HP-7, HP-12, HP-13, and HP-14) and pipelines in the Colville River Delta represent potential sources of spills that could affect the eiders and their habitat.

Marine Mammals

Any spills to the tundra that do not reach a flowing river or creek would not affect marine mammals.

Most spills are very small to medium in volume and are contained on the ice or gravel pads, roads, and airstrips. Most pipeline spills also are contained on the tundra, especially during the two-thirds of the year when there is snow and ice over the tundra and water bodies. There would be no impact of these spills to marine mammals.

Large spills that directly or indirectly enter flowing water of the rivers or creeks that discharge to Harrison Bay, the Colville River Delta (including the lower Nigliq Channel), and Kogru River mouth could have limited impacts on some of the marine mammals.

No impacts should occur to migrating bowhead whales whose migration route typically is well offshore of Harrison Bay and the immediately adjacent nearshore Beaufort Sea, where low concentrations of oil from a large spill might occur in open water season. Any spill reaching this marine environment would disperse to undetectable levels before it reaches migration routes and offshore habitats of the bowhead.

Some seals could be exposed to oil if a spill were to reach the marine environment of Harrison Bay or the areas they occupy in the Colville River Delta, lower Nigliq Channel, Kogru River, and the adjacent nearshore Beaufort Sea during the open water season. Such an event could result in the oiling of those seals directly exposed. It is possible, though unlikely, that a small number of these exposed seals could die, but the population would be likely to replace this loss within one year.

A large spill would not be likely to affect many bearded seals, walruses, beluga or gray whales because these species tend to occur offshore of Harrison Bay. Such a spill would be expected to disperse before it reached the migration routes and offshore habitats of these species. Such a spill would not be likely to have any food chain effects on marine mammals.

Polar bears would be most vulnerable to an oil spill were the spill to reach the coastal habitats of Harrison Bay. The number of bears likely to be contaminated or to be indirectly affected by a local contamination of seals probably would be small. Even in a severe situation where a concentration of perhaps 10 bears (such as at a whale-carcass site) were to be contaminated by the spill and all 10 bears were to die (a highly unlikely worst-case situation), this one-time loss would not be expected to affect the regional polar bear population.

In the CPAI Development Plan, a large spill from CD-3 or the pipeline between CD-3 and CD-1 where it crosses river channels or from the Nigliq Channel crossing are the most likely to have any impact on marine mammals, primarily polar bears foraging in the coastal areas and on seals in the Nigliq Channel. All other potential sources are far enough from the marine environment that spills are not likely to reach the marine mammals. There is a slightly reduced risk of large spills occurring in the ice-free season in Alternative D, compared to Alternatives A through C and F, because of the lack of vehicles and heavy equipment that might spill a container or tank of material or that could cause a rupture of a pipeline over a bridge, such as the Nigliq Channel or Ublutuoch River.

In the FFD, the same impact assessment is generally applicable. However, large spills from additional pads (HP-22, HP-5, HP-7, HP-12 to HP-14) plus the pipelines connecting them to flowing waters also could have similar impacts to marine mammals as described for CD-3.

Terrestrial Mammals

Most spills would be very small to medium volume and would remain on the ice or gravel pads, roads, and airstrips where they would be expeditiously cleaned. Some of the spilled material, especially from the medium spills, might reach the tundra adjacent to the gravel or ice structures. In addition, small spills from pipelines could reach the tundra anywhere along the pipeline and affect the tundra. These spills, especially oil, would have a very limited impact on the terrestrial mammals found in the Plan Area. The extent of impacts would depend upon the type and amount of materials spilled; the location of the spill; the type of habitat impacted; the mammals' distribution, abundance, and behavior at the time of the spill; and the effectiveness of the response. The proportion of habitat impacted would be very small relative to the size of the habitat utilized by most of the mammals. In addition, most of the mammals would not be present or would be limited in abundance and distribution in the Plan Area during the winter months; they would not be exposed to winter spills. The potential impacts to terrestrial mammals of these small to medium spills would be lower for Alternative D than for Alternatives A through C and F because the risk of spills to the habitat during the early summer through fall period is lower with the reduction of vehicle and equipment traffic.

A large spill that reaches the tundra adjacent to the gravel or ice pads, roads, or airstrips, or pipeline corridors could affect the terrestrial mammals directly or indirectly through impacts to their habitat and/or prey.

Caribou and other terrestrial mammals such as moose and muskoxen could become oiled by direct contact with oiled vegetation or soil, or by ingesting contaminated vegetation. Adult caribou, moose, and muskoxen that become oiled are not likely to suffer from a loss of thermal insulation during the summer, although toxic hydrocarbons could be absorbed through the skin or inhaled. However, the oiling of young calves could reduce thermal insulation, leading to their death (BLM and MMS 1998). Oiled caribou, moose, and muskoxen hair would be shed during the summer before the winter fur is grown. If caribou were oiled in the winter after shedding their summer coats, oiling would not be expected to substantially affect thermal insulation, because the outer guard hairs of caribou are hollow and thus retain their insulating properties even when coated with oil. No documented caribou deaths have been attributed to the spills associated with TAPS. Toxicity studies of crude-oil ingestion in cattle (Rowe et. al. 1973) indicate that anorexia (measurable weight loss) and aspiration pneumonia leading to death are possible adverse effects. Caribou, moose, and muskoxen that become oiled by contact with a spill in contaminated lakes, ponds, rivers, or coastal waters could die from toxic hydrocarbon inhalation and absorption through the skin.

A large spill would likely affect tundra vegetation, the principal food of the larger mammals. Caribou, moose, and muskoxen probably would not ingest oiled vegetation, because they tend to be selective grazers and are particular about the plants they consume (Kuropat and Bryant 1980). For most spills, control and cleanup operations (ground traffic, air traffic, and personnel) at the spill site would frighten caribou, moose, and muskoxen away from the spill and reduce the possibility of these animals grazing on the oiled vegetation. In most cases, onshore oil spills are not expected to affect caribou, moose, and muskoxen through ingestion of oiled vegetation. However, the spilled material could affect the vegetation and reduce its availability as food for several years (Section 4.3.3), though this impact would be limited in area and would not affect the overall abundance of food for the grazing mammals.

For large spills that are not immediately or successfully cleaned up, the potential for contamination would persist for a longer time and there would be a greater likelihood of animals exposed to the weathered oil. Cleanup success could vary depending upon the environment. Over time, any remaining oil would gradually degrade. Although oiling of animals would likely not remain a threat after cleanup efforts, some toxic products could remain for some time. Depending upon the spill environment, part of the oil could persist up to five years (BLM and MMS 1998).

Grizzly bears depend on coastal streams, beaches, mudflats, and river mouths during the summer and fall for catching fish and finding carrion. If an oil spill were to contaminate beaches and tidal flats along the Harrison Bay coast or the Colville River Delta, or the shore of other water bodies in the Plan Area, some grizzly bears would likely ingest contaminated food, such as oiled birds, seals, or other carrion (BLM and MMS 1998). Such ingestion could result in the loss of a few bears. Brown bears on the Shelikof Strait coast of Katmai National Park (an area contacted by the *Exxon Valdez* oil spill) were observed with oil on their fur and were consuming oiled carcasses (Lewis and Sellers 1991). A study of the exposure of Katmai National Park brown bears to the *Exxon Valdez* oil spill through analysis of fecal samples indicated that some bears had consumed oil or were exposed to oil; one young bear that died had high concentrations of aromatic hydrocarbons in its bile and might have died from oil ingestion (Lewis and Sellers 1991). Anecdotal accounts of polar bears deliberately ingesting hydraulic and motor oil, and foreign objects from human garbage sites, suggest that both bear species are vulnerable to ingesting oil directly, especially from oiled carrion and other contaminated food sources (Derocher and Stirling 1991). Skin damage and temporary loss of hair can result from oiling of bears, with adverse effects on thermal insulation (Derocher and Stirling 1991).

Small mammals and furbearers could be affected by spills due to oiling or ingestion of contaminated forage or prey items. These impacts would be localized around the spill area and would not have population level impacts.

A salt water spill could kill plants on contact and increase soil salinity to the point that many species could not survive (McKendrick 2000b). Unlike oil, salts are not biodegradable, and natural recovery occurs only after salts have leached from the soil. A spill would have adverse effects on salt-intolerant vegetation near the salt water spill, but the amount of tundra habitat affected would be small, usually no more than a few acres. Thus, potential salt water spills are not likely to affect forage availability for caribou, muskoxen, moose, or other terrestrial mammals in the Plan Area.

The impact assessment is also applicable to the FFD. In the FFD, several of the pads, roads, and pipelines, and thus potential for large spills, are closer to foraging habitats of grizzly bears and caribou than are the five satellite facilities of the CPAI Development Plan.

Economy

The vast majority of spills would be very small to medium size in volume, contained on the ice or gravel structures, or be limited to the tundra adjacent to the ice and gravel structures. They would not affect the local economy including the Helmericks commercial fishery on the Colville River Delta.

A large spill of oil, salt water, or chemicals that enters the Colville River from CD-3 or, in the FFD, from HP-4, HP-7, HP-12, HP-13, HP-14 or pipelines joining these pads, could potentially affect the commercial fish populations (e.g., arctic cisco, least cisco, and humpback whitefish) and/or the Helmericks fishing gear (Section 3.3.2). The nets, boats, personal gear, and other gear used in the fishery could become oiled if the oil reaches the fishing area. This could close the fishery, resulting in the loss of jobs and income for the family. In addition, depending upon the publicity the spill receives, the customer demand for potentially “tainted” fish could drop, resulting in a reduction or loss of demand for the fish and thus a reduction of loss of income and jobs.

Limited employment would be generated from cleanup of very small to medium spills (up to 1,000 gallons) on pads, roads, airstrips, or pipeline corridors. Even large spills of up to 100,000 gallons might not generate many additional jobs depending upon where the spill occurs. Onsite workers doing other operations and other response personnel from the North Slope, as well as other locations in Alaska, would clean up most small to medium spills. A large spill that enters the flowing water, especially where the oil strands along a substantial stretch of shoreline or river bank, would likely require the temporary employment of local village response teams and additional labor to clean up the oil.

Socio-Cultural Characteristics

Effects on the socio-cultural systems of local communities could come from interference with subsistence-harvest patterns from large oil spills and oil-spill cleanup as well as stress due to fears of a potential spill and the disruptions it would cause. Traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed for at least an entire season if there are concerns over the tainting of fish and other subsistence resources or potential displacement of subsistence resources and hunters. If a large spill contacted and extensively oiled coastal habitats, the presence of hundreds of humans, boats, and aircraft would displace subsistence species and would alter or reduce access to these species by subsistence hunters. The overall effects from these sources are not expected to substantially change ongoing socio-cultural systems.

Oil-spill employment (response and cleanup) could disrupt subsistence-harvest activities for at least an entire season and disrupt some socio-cultural systems but most likely would not displace these systems. The employment increase could have sudden and abnormally high effects, including inflation and displacement of Native residents from their normal subsistence-harvest activities by employing them as spill workers. Cleanup is unlikely to add population to the communities because administrators and workers would live in separate enclaves. Cleanup employment of local Inupiat also could alter normal subsistence practices and put stresses on local village infrastructures by drawing local workers away from village service jobs. Oil spills producing disruption of this magnitude are not expected from Northeast ASDP activities.

This impact assessment also applies to the FFD for the Plan Area.

Cultural Resources

Most spills are confined to a pad or roadway or to an area adjacent to them. The primary exceptions are spills from pipelines to tundra remote from the roads and pads. In the construction stage, most spills would occur on an ice pad or ice road during winter conditions, where snow and ice would limit impacts to cultural resources and cleanup would be less invasive than in a summertime terrestrial spill. Further, the type and location of cultural resources usually are clearly identified before construction begins so that they would not be affected by most spills or by subsequent spill cleanup. The effects of spills and spill cleanup associated with drilling and production would be similar to those associated with construction activities except that they could occur during the snow-free months. Although cleanup from these spills could be more invasive because of the non-frozen surface environment, there is little chance that cultural resources would be affected by either the spill or cleanup. Because the occurrence of most of the surface and subsurface cultural resources near the facilities are documented, the risk of impact is low.

This impact assessment also applies to the FFD for the Plan Area.

Subsistence Harvest and Uses

Impacts on subsistence-harvest patterns would result from impacts to subsistence resources. The direct and indirect effects of spills on individuals as well as populations of terrestrial mammals, birds, freshwater fish, marine fish, bowhead whales, beluga whales, and other marine mammals (ringed, spotted, and bearded seals; walruses; polar bears; and gray whales) are analyzed earlier in this section.

The vast majority of spills are very small to medium in size, are confined to the ice or gravel structures or immediately adjacent habitat or to the pipeline corridor, and are confined to relatively small areas even when they do affect the tundra or most tundra ponds, lakes, or small creeks. The potentially impacted areas would constitute a small proportion of the North Slope habitat utilized by the subsistence species. The spills and their associated cleanup activities under either the CPAI Development Plan or the FFD are not likely to affect subsistence resources or subsistence harvests.

Large spills, particularly those in remote sections of the pipelines or in the larger rivers and creeks, could affect a limited proportion of the habitat for subsistence species such as caribou or waterfowl, or a small proportion of the subsistence resource population itself. The direct and indirect ecological and physiological impacts to the resources are likely to be limited to the immediate area of the spill and could have a duration up to a year or two after the spill.

A large spill could result in a major response and cleanup effort, especially for a spill that is in habitat remote from the ice or gravel structures. The response could include the presence of hundreds of humans, boats, and aircraft that would displace subsistence species and alter or reduce access to these species by subsistence hunters. This impact would last as long as the major response activity continues, probably no longer than two seasons and generally less than one.

For large spills, especially of oil or hazardous substances, most of the subsistence resources would move to adjacent unaffected areas. As discussed more fully in Sections 4A through 4D and 4F.4.3, some of the subsistence users may follow the resources and other users may not utilize the resources because of concerns about contamination of the resources. From a technical "protection of human health" perspective, the resources may meet all government agency regulations regarding safety for ingestion or dermal contact in a relatively short time after the spill has been cleaned up. Often, one of the end points for determining that the cleanup can be terminated is that the food resources, water quality, and essential habitat variables meet government agency requirements for the protection of human health. These standards are typically based on physiological and toxicological (e.g., cancer health risk) criteria and not on cultural perceptions.

However, scientifically measurable quantities of contaminants in subsistence species, Traditional Knowledge criteria, and the perception of contamination by subsistence users are independent components contributing to the decision by subsistence users to harvest a resource. Subsequent to harvest, Traditional Knowledge-based criteria are used to determine the fitness of the harvested resource for consumption and the appropriate or safest method for preparation, consumption, distribution, and storage. In the case of contamination that shows no outward symptom or sign (e.g., PCBs, radioisotopes, and heavy metals, most of which are not an issue for the CPAI Development Plan or FFD), the perception of contamination is the basis for a behavioral response by subsistence users (Usher et al. 1995). This does not reflect a lack of sophistication on the part of subsistence hunters but rather a lack of the scientific tools and strategies (e.g., field test kits) for addressing a novel risk. Where the contamination event is undeniably evident, as in the *Exxon Valdez* oil spill, behavioral responses by subsistence users may be dictated by a number of other factors, such as resource availability, resource health, financial resources, and regulatory constraints (Fall and Utermohle 1999, Fall et al. 2001).

An illustrative example is the harvest of caribou, wherein a slow or weak animal, as demonstrated by a failure to try to flee hunters, is considered to be unhealthy independent of scientifically testable notions of contamination. Contamination by chemicals is only one possibility for this behavior, which may also stem from natural causes such as parasite overload, brucellosis, starvation, or injury (Usher et al. 1995). With no local expertise in environmental toxicology and no means to definitively test subsistence resources, the cumulative experience of generations of subsistence resource users is the final arbiter of the fitness for consumption of a resource. Traditional Knowledge of caribou health would direct the hunter to look for morphological anomalies in the meat and organs of the harvested animal to determine the fitness of the harvested animal for human or domestic animal consumption (Usher et al. 1995, Fall et al. 2001). Inupiat hunters interviewed in 2003 approached these anomalies based on their judgment and experience, with some choosing to discard some or all of a caribou found to be sick after harvest while others selectively removed parts deemed unfit for consumption (SRB&A 2003a).

For all resources, the perception of contamination in the absence of testing (e.g., abscesses, pus spots, discoloration, anatomical deformity, and taste) or the tested presence of contaminants at levels deemed acceptable by the government may discourage resource users from harvesting and consuming the resource for multiple harvest seasons. If harvesters perceive the resource habitat or traditional harvest location to be contaminated, they may go farther from the community or traditional harvest location to harvest uncontaminated resources (Fall and Utermohle 1999). Possible results of this change may be shifts in species emphasis, the need to purchase some formerly subsistence foods to reinforce perceptions of safety, and the need to expend more time, effort, and money pursuing resources at more distant locations with greater commensurate accident risks for some modes of travel (Fall and Utermohle 1999, Fall et al. 2001).

Land Uses and Coastal Management

The vast majority of all spills are confined to a pad, road, or airstrip, to an adjacent area, or to the area under a pipeline. Spills that impact the tundra or water, whether the source is a pipeline, bridge, culvert, or pipeline over water, could affect land uses or Coastal Management policies and regulations.

Most small spills are quickly contained or cleaned up. The impacts of such spills are expected to be minor, especially given the required measures addressing prevention and response described in Section 2. No conflicts with any of the land uses or statewide standards or district enforceable Coastal Management policies are anticipated.

A large spill, especially if it reaches a water body such as the Nigliq Channel or Ublutuoch River, could influence local subsistence resources, habitats, and land and water quality in the Plan Area. If a spill occurs during the winter months, cleanup efforts would be conducted during the winter months and would be less likely to affect the resources or uses of the coastal zone. However, even if a large spill were to occur during the summer months, it is not anticipated that any species would become unavailable or unharvestable because of such a spill. While localized availability and harvestablility could be affected, it is expected that subsistence activities could continue outside the localized spill area. Water quality in the area of the spill could be compromised but the effect would be short term. Habitats also would be influenced locally if a spill were to occur during summer months or break-up. Oil that is stranded on shorelines may persist for several years to decades, depending upon the type of oil and exposure to physical and biological weathering processes.

This impact assessment also applies to the FFD for the Plan Area.

Recreation Resources

Most spills are very small to small and few are medium to large. Nearly all of these spills would be confined to pads, roads, airstrips, or the immediate vicinity, and to the pipelines. Therefore, impacts on wilderness-type values of scenic quality, solitude, naturalness, or primitive/unconfined recreation resulting from spills likely would be confined to the same area.

A large spill, most likely from a pipeline or from a tank truck accident that reaches a creek or river (e.g., Ublutuoch River) including the Nigliq Channel in the break-up to initial freeze-up season could move rapidly downstream. The spilled material, especially oil, might be visible and thus could have a short-term (and possibly long-term) impact on recreation values. Fishing, boating, camping, scenic values, and other recreation pursuits could be affected as a result of an oil spill in a riverine environment that is used by recreationists. The obvious short-term effects would be the oil residues in areas of use. The long-term effects would possibly be the reduction or loss of fishing and diminished scenic value of the area, as oil residue could take a long time to weather and would not be detectable.

A spill of salt water and other miscible materials could have less short-term impact on recreational uses because it could be less visible. However, it could affect the fish, birds, and, over a longer period, the vegetation, which could diminish the recreational value and use of these resources.

This impact assessment also applies to the FFD for the Plan Area.

4.3.4 VERY LARGE VOLUME SPILLS

4.3.4.1 Introduction

This section evaluates the rate of a VLVS; greater than 100,000 gallons) (Section 4.3.2 for spill sizes) and the potential impacts to the environment for both the CPAI Development Plan and the FFD.

A review of the ADEC North Slope spill database for 1995 to 2003 (ADEC 2003d) shows one VLVS in March 1997 of 994,400 gallons of salt water at DS 4 in the Prudhoe Bay Unit when salt water broached to the surface and was completely contained on the pad (B. Smith, pers. comm. plus excerpts of the Incident Report of the Investigation Team). One other spill occurred that approaches the VLVS criterion of greater than 100,000 gallons: a 92,400-gallon produced water spill resulting from corrosion at APF-1 in April 2001. Mach et al. (2000) report only one Alaska North Slope oil spill of 100,000 gallons and that was jet/turbine fuel spilled in 1982 by Wien Airlines at the Deadhorse Airport. It was not a spill from the oil field operations. No very large volume oil spills have been reported since January 1995; the largest was a 38,000-gallon crude oil spill. None of these spills occurred at the Alpine Unit.

A further review of the 1971 to 1994 ADEC database[19] for spills on the North Slope shows approximately 6,900 spills, most of which occurred in the oilfields[20,] and shows 4 spills estimated to be greater than 100,000 gallons. All occurred at gravel pads between 1983 and 1991. They include 1,050,000-, 420,000-, and 147,000-gallon spills of drilling mud, and 357,000 gallons of produced water. No other VLVSs were reported of salt water, produced fluids, or oil in the North Slope oilfield before 1995.

4.3.4.2 VLVS Scenarios

The VLVS scenario has been analyzed for crude-oil spills in several North Slope environmental evaluations, which are incorporated by reference (BLM and MMS 2003, BLM and MMS 2002, TAPS Owners 2001a, PAI 2002a, CPAI 2003f). The definition of a VLVS varies among these documents, depending on the situation being analyzed and the potential source of the spill. The volume ranges from approximately 117,600 to 126,000 gallons (MMS 2002, PAI 2002a) to 5,040,000 gallons (BLM 2003b), based on various risk assessments.

For purposes of a cleanup response scenario, the CPAI Alpine ODPCP (CPAI 2003f) for the existing Alpine field wells uses a VLVS of 3,591,000 gallons for a well blowout. This value is based on known production rates

---

[19] According to Luick (pers. comm. 2003), the pre-1995 database was compiled in R-Base and the input data did not always provide information in a complete and/or consistent manner for every incident. However, the database provided to ENTRIX by the ADEC is sufficient to provide a general picture of the pre-1995 North Slope spill history for this scenario development and impact analysis.

[20] Spills at Barrow and other North Slope areas (but not oilfield locations) are included. However, they do not constitute many spills (the exact number was not determined) and do not materially change the following discussion. The one exception is for VLVS. Besides the four described in this paragraph, there were five other VLVSs at North Slope villages or other locations.

of the wells along with the appropriate ADEC-approved credits taken, and accounts for evaporation and volatilization of the light ends (e.g., benzene, toluene), but without considering that as much as 80 percent of the material from a blowout could be non-oil (i.e., brine, natural gas, grit). A second possible VLVS assumes approximately 43,134 gallons of sales oil could reach the Colville River by flowing over the tundra. As indicated in Table 2.3.11-2, pads are generally greater than or equal to 0.5 miles from rivers and creeks, so most of the fluids from a blowout would be deposited on tundra and associated ponds or lakes.

For the proposed CPAI Development Plan and the FFD, the potential well production characteristics and rates are not known (Shifflett, pers. comm. 2003) so the ADEC blowout default values of 231,000 gallons per day for 15 days could be used to provide a total of 3,465,000 gallons of produced fluids that potentially could be spilled. Some of this would evaporate and some (perhaps the majority) would consist of natural gas, which would volatilize.

Another possible VLVS scenario is the rupture of the proposed pipelines for produced fluids or salt water, and for the FFD, the Sales Oil Pipeline crossing the Nigliq Channel or other major rivers and creeks (Table 4.3.3-1). If only one of the co-located pipelines were severed completely between valves or vertical loops, up to approximately 195,000, 450,000, and 5,600 gallons of produced fluids, salt water, or diesel, respectively, could be discharged from the pipeline. For the FFD, up to 330,000 gallons of Sales Oil Pipeline could potentially be spilled to the tundra and 23,100 gallons of Sales Oil to the Nigliq Channel if a new pipeline were required to transport oil from HPF-1 and/or HPF-2 to APF-1, and if the pipeline were located on the bridge. If all the co-located pipelines were completely ruptured (e.g., because of a truck or heavy equipment crash, or loss of a bridge in a major flood) in the CPAI Development Plan, total spill volumes potentially could amount to approximately 32,000 gallons at the Nigliq Channel and Ublutuoch River crossings, and approximately 220,000 gallons in the Colville River Delta between CD-1 and CD-3. A complete rupture of the lines between CD-6 and CD-7 could potentially result in a spill of approximately 523,000 gallons on the tundra and/or tundra ponds and lakes between the pads. This tundra spill is intended to represent spills between any of the production pads in the CPAI Development Plan and between production pads and the hypothetical processing facilities (HPF-1 and HPF-2) in the FFD, though the volume spilled would likely be smaller in most instances.

This EIS considers spills from greater than 100,000 gallons to the hypothetical maximums postulated for the CPAI ODPCP (for example, 4,725,000 gallons) to be VLVSs in terms of the potential impacts. In addition, for purposes of this analysis, a VLVS is a spill that would affect a substantial area of tundra and possibly surface water beyond gravel pads, roads, or airstrips and that could require substantial resources from the North Slope for response, control, and cleanup.

4.3.4.3 Rate of Very Large Volume Spills

Five VLVSs have been reported for the North Slope oilfield since 1977 in the ADEC databases, and the total oil production has been approximately 1.6 trillion gallons in that time (www.tax.state.ak.us/programs/oil/production/index.asp). This amounts to approximately one VLVS for every 300 billion gallons of oil, and none of these VLVSs consisted of oil or produced fluids. Another indicator is that approximately 2,968,000 gallons of material (none that are oil or produced water) were spilled only in VLVS or approximately one gallon spilled for every 540,000 gallons of oil produced from the North Slope. Thus, the rate of occurrence of VLVSs of oil (or oil in produced fluids) in the Plan Area approaches zero. This rate is still extremely low for all hazardous materials combined.

Based on the recent history of reported North Slope spills and proposed oil production in the CPAI Development Plan, the most likely potential VLVSs would be composed of produced fluids or salt water. The occurrence of VLVS of drilling muds from reserve pits is much less likely now than it was pre-1995 because of the changes in drilling operations and procedures for handling drilling muds. In particular, reserve pits are no longer used on the North Slope. The largest hypothetical spills would be produced fluids from a well blowout which have not yet occurred on the North Slope. The actual largest spills in the ADEC 1995-2003 database are of salt water and produced water.

Therefore, the following VLVS impact assessment is based primarily on potential spills of produced fluids and/or salt water.

4.3.4.4 Behavior and Fate of a Very Large Volume Spill

A VLVS would most likely result from a major pipeline break, well blowout, or uncontrolled release. In the latter two cases, some or much of the spilled material could be contained on the pad or on the tundra in the immediate vicinity. However, in all three cases, there is a high likelihood that the oil and/or salt water would affect the tundra, possibly relatively remote from the road or pads in pipeline spills. Depending upon proximity and season, the oil and/or salt water could also reach wet tundra, tundra ponds and lakes, creeks, larger rivers, estuaries, Harrison Bay, and the nearshore Beaufort Sea.

The processes that affect the fate and behavior of the spilled material are described in Sections 4.3.2.3 and 4.3.2.4, as well as in several previous North Slope EISs, which are incorporated by reference. The primary difference between the discussion about behavior and fate of very small to large spills and VLVSs, is the larger scale of the VLVSs, i.e., generally a larger area would be affected, the duration of the impact would be greater, the magnitude of the impacts would be greater, the time required for weathering would be longer, and the response/cleanup effort could be much greater.

In summary, the behavior and fate of a VLVS from the CPAI Development Plan or the FFD would be influenced by the following factors:

- Type and volume of material spilled
- Duration of the release (e.g., essentially instantaneous in a pipeline rupture compared to an extended period for a well blowout)
- Topography of the tundra or water bodies
- Season (including temperature, wind, and precipitation)
- Water velocity and flood stage if spill reaches flowing waters
- Response actions
- Vegetation, snow and ice cover

WINTER SEASON

During the two-thirds of the year when the tundra typically is covered with snow, the water bodies are covered with ice, air temperatures are well below freezing, and there is little, if any, water flow in rivers, a VLVS generally would be limited in aerial dispersal far from the source. Oil would cool rapidly to a point where the viscosity is high, and dispersal would be limited. However, a large volume release of warm oil released as a fluid, rather than a mist or spray to the tundra, may melt through snow to the tundra vegetation and underlying soil before the oil cools enough to stop flowing. The snow would act as a sorbent and retain much of the oil once the oil cooled. VOCs will evaporate more slowly than in warmer periods so the potential toxicity of the oil to vegetation, fish, and wildlife would last longer. However, there are generally fewer biological resources other than tundra vegetation to be exposed to the oil in winter. Salt water will begin to freeze[21] when temperatures are well below freezing. Both the oil and salt water could be removed from the tundra or water surfaces before they become incorporated into the soil, vegetation, or water over large areas. Also, the response actions to contain and clean up the spilled material would be less environmentally damaging if they are implemented to minimize surface disturbance or removal of vegetation and soil.

SPRING BREAK-UP

During spring break-up, snow melts off the tundra and the snowmelt, as well as rain ponds in depressions in the tundra or runs off to the creeks and rivers. The river water levels rise to flood stage and "break up" the ice in the

[21] Seawater with a salinity of 3.3 percent salt begins to freeze at approximately 28°F. As indicated by the presence of landfast sea ice in Harrison Bay and the nearshore Beaufort Sea, seawater can freeze rapidly to substantial thickness in a few days to weeks.

rivers. The ice and floodwaters are transported downriver, eventually to Harrison Bay where the freshwater floods over the landfast sea ice. The floodwaters also could overtop the riverbanks and temporarily flood the tundra, tundra ponds, and lakes.

During break-up, a VLVS of oil to the dry tundra could be limited in its dispersal because of the sorbent effect of the vegetation and/or snow. However, the oil could still cover several acres to tens of acres of tundra, and possibly more if it is aerially dispersed in a blowout. Oil spilled on wet tundra could be dispersed over a larger area as the wind blows it across the water surface and/or the sheet flow takes it toward the creeks, rivers, or tundra ponds and lakes. Oil spilled to tundra lakes and ponds would disperse over the water surface but eventually would collect on the downwind shores where vegetation would trap it. Oil spilled to flowing waters, especially the larger creeks and rivers (e.g., Nigliq Channel, Colville River Delta, Ublutuoch River, Fish and Judy Creeks, Kogru and Kalikpik rivers), would rapidly disperse in the flood waters and broken ice and be transported downstream toward Harrison Bay and the nearshore Beaufort Sea. The fate of this oil would depend largely upon the location of the spill and the volume and velocity of flood flows.

A VLVS of salt water would undergo much the same behavior and fate. However, the key difference for spills that reach flowing waters and large volume tundra lakes is that salt water would be rapidly diluted to ambient salinity of fresh water and therefore lessen its impact to the natural aquatic habitats. A VLVS to the tundra could kill or injure vegetation over the area exposed to the salt water.

Cleanup of oil spills during break-up is more challenging than in the winter. The CPAI ODPCP provides details of the necessary response actions, training programs, required equipment, etc.

SUMMER

In summer, a VLVS to the tundra would be limited in dispersal where the soil is relatively dry and the vegetation is at peak growth, thereby increasing the sorbent effect it has on oil. In addition, the VOCs would evaporate more quickly than in winter because of the higher air temperatures. Salt water could infiltrate farther into the soil than oil could to fill the interstices that were filled with ice in the winter. The warmer air temperatures would result in lower viscosity of oil, and salt water would remain liquid. In both cases, this would increase the dispersal over tundra, especially wet tundra, despite the sorbent effect of the vegetation. Spills to flowing water would be transported downstream but the velocity of transport and distance could be less than during break-up. More of the oil would be trapped in the vegetation and sediments of the riverbanks. The rate of dilution of salt water would not be as great as during break-up, and the salt water could cause higher salinities for longer in the freshwater systems.

FALL FREEZE-UP

During the freeze-up period, a VLVS of oil to the tundra would be similar to one in winter except there could be less snow and ice cover, and the snow could come and go for a few weeks. The air temperatures would not be as consistently cold so the viscosity of the oil and the evaporation of VOCs would vary with air temperature. Oil spilled to tundra ponds and lakes could become incorporated into the vegetation and soil, as well as the ice cover. As the ice freezes, the oil could become trapped unless it is removed during cleanup, an action that would be influenced by the thickness and strength of the ice. Oil spilled to flowing water could also become incorporated into or under the ice, not to be released until the following break-up and summer periods.

Salt water spills could become slush or solid ice, depending upon the temperature. This could enhance the removal where it is the appropriate response strategy.

4.3.4.5 Effects of Very Large Volume Spills

OVERVIEW

A VLVS is most likely to result from a major pipeline break, a well blowout, or uncontrolled release from a drilling or production pad. In the latter two cases, some (and possibly much) of the spilled material could be contained on the pad or on the adjacent tundra. However, in all three cases, there is a high likelihood that the oil and/or salt water would affect several to hundreds of acres of tundra and, in the case of pipeline spills, possibly relatively remote from the road or pads. The oil and/or salt water could also reach wet tundra, tundra ponds and lakes, creeks, larger rivers, estuaries including the Colville River Delta, Harrison Bay, and the nearshore Beaufort Sea, with the amount depending largely upon proximity of the spill source to the water bodies, season, and volume of the spill. In summary, a VLVS is more likely to affect a greater area and diversity of natural habitats and resources than are very small to large spills described in Section 4.3.3.

The range of potential impacts of very small to large spills is summarized in Section 4.3.3, as well as in several previous North Slope EISs, which are incorporated by reference. The primary difference between the previous discussion about potential impacts of very small to large spills and VLVSs is the larger scale of the VLVSs, i.e., generally a larger area is affected, duration of the impact is greater, magnitude of the impacts is greater, the time required for weathering is longer, and the response and cleanup effort could be much greater.

Therefore, the impact assessments from Section 4.3.3.3 are incorporated by reference into the following impact assessment of VLVSs in the CPAI Development Plan and FFD. The resource and issue categories in Section 4.3.3.3 are consolidated into physical, biological, and social/cultural/economic environments. These sections summarize the major differences in the impacts, mostly in magnitude and in areal extent, particularly into Harrison Bay and the nearshore Beaufort Sea.

PHYSICAL ENVIRONMENT

A VLVS could result in a thicker, continuous layer of oil over a larger area than smaller spills and may result in increased thermokarsting and potential incorporation of oil into the soil voids.

The impact to paleontological resources would be similar to that for small to large spills. Paleontological resources are typically subsurface, and the oil or salt water would not penetrate far into the soil.

Freshwater water quality and water resources are likely to experience greater impacts because the amount of oil or salt water relative to the volume of potentially influenced freshwater bodies would be greater, especially in tundra ponds, lakes, and wetlands where there is low to no flow. Therefore, the potential concentration of toxic materials or salts could exceed toxicity thresholds for aquatic plants, fish, and macroinvertebrates. In flowing waters, the relatively greater proportion of oil or salt water could result in more oil reaching the sediments and shoreline vegetation further downstream than for small to large spills.

The greatest difference in impacts to the physical environment is likely to be in the estuarine and marine water quality and to be largely limited to oil spills. Because the volume of oil in a VLVS is large, more of the oil is likely to reach the estuarine and marine environments of Harrison Bay and nearshore Beaufort Sea than in smaller spills, even if the spill were to occur well upstream on a major river or creek (e.g., at the Ublutuoch River crossing near CD-6 or in the FFD at HP-17 near Judy Creek or HP-8 near Nuiqsut). For VLVSs that occur near the Colville River Delta, Harrison Bay, or Beaufort Sea (e.g., for CD-3, Nigliq Channel crossing; for FFD, HP-7, HP-12, HP-13, HP-14, and HP-22), the oil is likely to quickly reach the estuarine and marine environments in relatively large amounts and relatively unweathered. In Alternative C where the Nigliq Channel crossing is further upstream toward Nuiqsut, a VLVS of oil may still reach the Harrison Bay area, though the total volume would likely be reduced compared to a spill from a crossing farther north.

BIOLOGICAL ENVIRONMENT

A VLVS of oil and/or salt water could affect several to tens or potentially hundreds (in a blowout) of acres of vegetation. The major difference from small to large spills is the greater areal extent of oiling or salt water inundation. A VLVS from FFD pads HP-13, HP-5, HP-7, HP-12, HP-13, and HP-14, as well as from the pipeline joining them, could affect more halophytic vegetation than would the CPAI Development Plan, which has only CD-3 on the Colville River Delta.

Freshwater fish populations are likely to be affected in the tundra ponds and lakes, as well as creeks and river channels, exposed to the oil and/or salt water. As discussed for freshwater quality (Section 4.3.3.3), toxic concentrations could exceed toxicity thresholds especially in smaller water bodies. Also, if the oil is discharged under ice or is entrained under the ice through cracks in it, especially in the Colville River or Nigliq Channel, it could collect in the deep pools where it has the potential to (1) depress dissolved oxygen levels as a result of the biodegradation of the oil, even at low microbial density and activity levels, and (2) exceed acute and chronic toxicity levels. Similarly, a VLVS of salt water, which is substantially denser than fresh water and would sink, could collect in these pools in winter if the salt water found cracks in the ice. The high salinity could cause osmotic stress in the fish and cause mortalities. There is no escape in winter for the fish from these reservoirs.

Unlike the impact assessment for small to large spills, a VLVS of oil could reach the marine environments of Harrison Bay and, especially in the FFD, nearshore Beaufort Sea (e.g., near HP-22) in concentrations and volumes great enough to contact the nearshore marine fish and benthic community. The impact is likely to be localized because the spilled oil would be diluted rapidly in the large volume of marine water and the toxic components would evaporate rapidly. Also, marine fish do not usually suffer many mortalities as a result of oil spills unless they are trapped in bays or similar areas. The benthic organisms could be exposed and some could die from the toxic effects of oil in the water or in the sediments. Again, the spatial extent is likely to be localized around the river discharge area.

A VLVS of oil is likely to affect substantially more shorebirds, passerines, gyrfalcons, hawks, and other terrestrial birds than would a small to large spill. The areal extent and thus potential for direct or indirect exposure increases with the VLVS. The number of individuals exposed and affected would not likely have an impact on the regional population size. Waterfowl, loons, geese, gulls, endangered spectacled eiders, and other birds that spend much to most of their time on the water resting, feeding, or molting, or nesting immediately adjacent to the water, could be impacted in large numbers, depending upon the distribution of oil, behavior of the birds, and their density. If large volumes of surface oil reach the estuarine portions of the rivers, the Colville River Delta, mouth of Nigliq Channel, or Harrison Bay during the summer season, large numbers of birds would likely be oiled and ultimately die. The probability is greater in the FFD because more pads and pipelines in the Colville River Delta and coastal habitats are key nesting, resting, feeding, and molting/staging areas for these migratory birds. In addition to the expected mortality due to direct oiling of adult and fledged birds, impacts could also include mortality of eggs due to secondary exposure by oiled brooding adults; loss of ducklings, goslings and other non-fledged birds due to direct exposure; and lethal or sub-lethal effects due to direct ingestion of oil or ingestion of contaminated foods (e.g., insect larvae, mollusks, other invertebrates or fish).

Marine mammals in the Colville River Delta, lower Nigliq Channel, Harrison Bay, and possibly the nearshore Beaufort Sea have a greater probability of exposure to oil in VLVSs than in small to large ones for the same reasons birds do. Even a VLVS (unless it approaches millions of gallons) from the CPAI Development Plan or the FFD is unlikely to affect bowhead whales or other marine mammals outside Harrison Bay.

Terrestrial mammals could be affected over several acres to tens or hundreds of acres in a VLVS, (especially of oil). They would tend to avoid oiled areas and thus lose a measurable though small proportion of available forage habitat. The risk of direct contact with oil and thus potential injury or death increases over that of small to large spills. Most of the larger mammals could avoid the oiled area. The loss of vegetation from oil and/or salt water spills is measurable but would not constitute a substantial portion of the available forage.

SOCIAL/CULTURAL/ECONOMIC ENVIRONMENT

The economy, socio-cultural, and cultural aspects of the North Slope could be affected by a VLVS. A VLVS of oil that enters the Colville River from CD-3 or for the FFD, from HP-4, HP-7, HP-12, HP-13, HP-14, or pipelines joining these pads, would likely affect the commercial fish populations and/or the Helmericks fishing gear for at least one fishing season and maybe longer if it directly affected the fishery areas (Section 3.3.2.5 for discussion of the commercial fishery). This could close the fishery resulting in the loss of jobs and income for the family.

VLVSs could generate many additional jobs depending upon where the spill occurs. Onsite workers doing other operations and other response personnel from the North Slope including trained responders from the Barrow and Nuiqsut response teams, as well as other locations in Alaska, would conduct the initial responses. A VLVS of oil that enters the flowing water, especially where the oil strands along a substantial stretch of shoreline or riverbank, could require the temporary employment of additional labor to clean up the oil. Some of this labor would come from the North Slope population while much of it would come from outside contractors, spill response organizations, and other sources identified in the CPAI ODPCP.

Effects on the socio-cultural systems of local communities could come from interference with subsistence-harvest patterns from both the physical impacts of VLVS of oil and oil-spill cleanup as well as stress due to fears of a potential spill and the disruptions it would cause. Traditional practices for harvesting, sharing, and processing subsistence resources could be seriously curtailed for at least an entire season and possibly longer if there are concerns over the tainting of fish and other subsistence resources or potential displacement of subsistence resources and hunters. If a VLVS contacted and extensively oiled coastal habitats, the presence of hundreds of humans, boats, and aircraft would displace subsistence species and alter or reduce access to these species by subsistence hunters. The overall effects from these sources are not expected to displace ongoing socio-cultural systems but these systems could be disrupted for several years.

Oil-spill employment (response and cleanup) could disrupt subsistence-harvest activities for at least an entire season and disrupt some socio-cultural systems; however, it would probably not displace these systems. The sudden employment increase could have sudden and abnormally high effects, including inflation and displacement of Native residents from their normal subsistence-harvest activities by employing them as spill workers. Cleanup of a VLVS is unlikely to add population to the communities because administrators and workers would live in separate enclaves. Cleanup employment of local Inupiat also could alter normal subsistence practices and put stresses on local village infrastructures by drawing local workers away from village service jobs.

A VLVS (especially of oil) could affect certain types of cultural resources if they are near water bodies and above the ground surface (e.g., hunting camps). The type and location of cultural resources usually are clearly identified before construction of a facility so that the cultural resources would not be affected by most spills or by subsequent spill cleanup. Although cleanup from these spills might be more invasive because of the non-frozen surface environment, there is little chance that either the spill or cleanup would affect cultural resources. Because the occurrences of most of the surface and subsurface cultural resources near the facilities are documented, the probability of impact is low.

VLVSs of oil or salt water could affect up to several hundred acres of the habitat for subsistence species such as caribou or waterfowl, particularly those in remote sections of the pipelines or in the larger rivers and creeks. The direct and indirect impacts to the subsistence species are likely to be limited to the immediate area of the spill and could have a duration up to several years after the spill. Most of the motile subsistence resources (e.g., birds, mammals, and fish) would move to adjacent unaffected areas and some of the subsistence users would likely follow the resources. From a technical "protection of human health" perspective, the resources may meet all government agency regulations regarding safety for ingestion or dermal contact in a relatively short time after the spill has been cleaned up. For all resources, the perception of contamination in the absence of testing (e.g., abscesses, pus spots, discoloration, anatomical deformity, and taste) or the tested presence of contaminants at levels deemed acceptable by the government may still discourage subsistence resource users from harvesting and consuming the resource for multiple harvest seasons (i.e., several years). If harvesters perceive the resource habitat or traditional harvest location to be contaminated, they may go further from the community or traditional harvest location to harvest uncontaminated resources (Fall and Utermohle 1999). Possible results of this change may be shifts in species emphasis, the need to purchase some formerly subsistence foods to reinforce perceptions of safety, and the need to expend more time, effort, and money pursuing resources at more distant locations with greater commensurate accident risks for some modes of travel (Fall and Utermohle 1999, Fall et al. 2001).

A VLVS would result in a major response and cleanup effort, especially for a spill that is in habitat remote from the ice or gravel structures. The response could include the presence of hundreds of humans, boats, and aircraft that would displace subsistence species and alter or reduce access to these species by subsistence hunters. This impact would last as long as the major response activity continues, probably no longer than two seasons, and generally less than one.

A VLVS that reaches a creek or river (including the Nigliq Channel) in the break-up to initial freeze-up season could move rapidly downstream. The spilled material (especially oil) could be visible and thus could have a short-term (and possibly long-term) impact on recreation values. Fishing, boating, camping, scenic values, and other recreation pursuits could be impacted as a result of an oil spill in a riverine environment that is used by recreationists. The obvious short-term effects would be the oil residues in areas of use. The long-term effects would possibly be the reduction or loss of fishing and the diminished scenic value of the area, as oil residue could take a long time to weather to the point it is not detectable. A VLVS of salt water is likely to have less short-term impact on recreational uses because salt water is less visible than oil. However, a salt water spill could affect the fish, birds, and, over a longer period, vegetation, which could affect the recreational value and use of these resources.

A VLVS spill requiring a large contingent of cleanup personnel and equipment cleanup on the tundra, especially on a creek or river, or a large tundra lake, could have a temporary impact on the viewshed.

4.3.5 MITIGATION MEASURES

Most of the "mitigation measures" focus on prevention of spills or the rapid and efficient containment and cleanup of those spills that do occur. Most of these measures are incorporated into the design and operation/maintenance procedures for the oilfield and are described in Section 2. They include a detailed ODPCP that would be prepared by CPAI for the project facilities as they are constructed and put into production.

Additional mitigation measures to reduce the probability of a spill, reduce the volume potentially spilled, or decrease response time include:

- Install automatic shutdown isolation valves, or vertical loops in the salt water and diesel pipelines on each side of the major creek or river crossings. These crossings include Nigliq Channel (except in Alternative D), Ublutuoch River, and Tamayayak Channel in the CPAI Development Plan. For the FFD, additional crossings could include Fish-Judy Creeks, Kalikpik River, and the Colville River (if an additional Sales Oil line is required). These valves should be capable of automatic shutdown and closure from a remote location (e.g., APF-1), as well as manual closure. The goal is to minimize the amount of spilled material that might enter these rivers and creeks in the event of a leak, and especially in the event of a complete pipeline rupture.
- In Alternatives A through C, conduct regular and frequent visual inspection of the pipelines on the bridge crossing the Nigliq Channel during break-up floods, especially in the larger flood events (e.g., greater than or equal to a 50-year flood level). The inspection would identify any potential problems with the integrity of the bridge because of ice jams, erosion and scour, etc., as well as determine if there are additional risks of pipeline failure and a need to reduce or stop flows until integrity is assured. These inspections would be more frequent than the routine inspections of the pipeline system already included in Section 2.

An additional recommendation is to require that CPAI and other potential operators in the FFD scenario collaborate with the appropriate state, federal, and Native government agencies to evaluate the benefits of and need for conducting a basic monitoring program for each spill that reaches the wet or dry tundra and/or water bodies including tundra ponds, tundra lakes, creeks, rivers and estuaries. The primary goal would be to determine (1) the type, magnitude, and duration of detectable community and population-level impacts from the spilled material, as well as the cleanup actions, and (2) the recovery process of the impacted habitats and measurably affected resources. The details regarding duration, areal extent, parameters to measure, and other elements of a monitoring program would be developed on a case-by-case basis. The resulting information would be made publicly available, probably on a current web site. The purpose for this information would be to provide a more quantitative basis than exists at present for evaluating impacts of future potential and actual spills on the North Slope and to evaluate the benefits and costs of natural and anthropogenic restoration processes.